SPECIAL ANNIVERSARY EDITION *20 Years Since Apollo 11*

AIR&SPACE

Smithsonian • June/July 1989

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from *Columbia* on
July 20, 1969**

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Voyage to the Moon

Wanderer in our skies,
dazzle of silver in our leaves and on our
waters silver, O
silver evasion in our farthest thought—
"the visiting moon," "the glimpses of the moon,"

and we have found her.

From the first of time,
before the first of time, before the
first men tasted time, we sought for her.
She was a wonder to us, unattainable,
a longing past the reach of longing,
a light beyond our lights, our lives—perhaps
a meaning to us—O, a meaning!

Now we have found her in her nest of night.

Three days and three nights we journeyed,
steered by farthest stars, climbed outward,
crossed the invisible tide-rip where the floating dust
falls one way or the other in the void between,
followed that other down, encountered
cold, faced death, unfathomable emptiness.

Now, the fourth day evening, we descend,
make fast, set foot at last upon her beaches,
stand in her silence, lift our heads and see
above her, wanderer in her sky,
a wonder to us past the reach of wonder,
a light beyond our lights, our lives, the rising
earth,

a meaning to us,

O, a meaning!

—*Archibald MacLeish*

AIR&SPACE
Smithsonian

June/July 1989
Volume 4, Number 2

AIR&SPACE

Smithsonian

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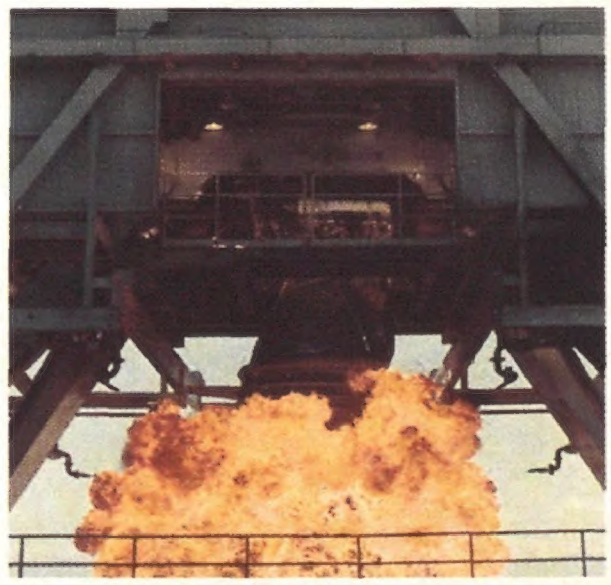
AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bimonthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, DC 20560. Subscription price: $18 a year in U.S. possessions, $24 elsewhere. Eighty-five percent of dues is designated for magazine subscription. Single-copy price: $3.50. Second-class postage paid at Washington, DC, and additional entry points. Editorial offices: 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Advertising and circulation offices: 420 Lexington Ave., New York, NY 10170. Members: Address all subscription correspondence and change-of-address information to P.O. Box 53261, Boulder, CO 80322-3261. Postmaster: Send address changes to AIR & SPACE/Smithsonian, P.O. Box 53261, Boulder, CO 80301-3261.



Special Edition: Remembering Apollo

Cover: *Sculptor Leo Monahan created a moon, Earth,* Eagle, *and* Columbia *in paper to celebrate the moment when the two spacecraft separated prior to man's first descent to the moon.*

Hypothesis

Put your memory and imagination to work testing this proposition: the Apollo program would not have a chance of succeeding in 1989. Interesting, isn't it? At first you agree, then you squirm a little and scramble for some encouraging sign that if we wanted to, we could bring back the astronauts and Saturns and lunar modules and do it all over again.

This special edition of *Air & Space/Smithsonian* began with just that sort of speculation. As we thought about Apollo, we realized that we had more than just one long feature article by the tail. The result is the first issue of *Air & Space/Smithsonian* designed to thoroughly explore a single idea. (In the August/September issue, we'll return to our traditional menu of aviation and space features.)

Early in the game, we became wary of a dangerous temptation—to celebrate this anniversary by lighting the stage in the golden afternoon glow of nostalgia and then just lying back and basking in it. Weren't those wonderful times? The nation was prosperous, the people were happy—right? There are those who cling to memories of Apollo because it seemed to unite the nation behind a single, noble purpose. We were so *together* back then. NASA was powerful, heroic, untarnished—and best of all, driven. You don't have to listen very hard to hear critics of today's U.S. space program whispering "Apollo" between the lines.

But the more we worked on reconstructing the Apollo program and the state of the nation during that period, the clearer it became that Apollo was a fluke: it would not—could not—be repeated because it depended so much on specific events and circumstances. That's hardly an earth-shaking observation—World War II won't happen again either. But we seem to have some deep national yearning to regain what we had in the past; there are even people who recall the war with nostalgia and blithely forget its horrors.

Apollo was not born of some noble aspiration to elevate humankind, as you'll read in Wayne Biddle's examination of John Kennedy's motives in sending men to the moon. Kennedy was practicing politics, plain and simple. And Kennedy was not alone. As Phillip S. Clark's report explains, during most of the 1960s the Soviet Union was equally determined to place a man on the moon, though not so willing to talk about it.

Achievement of that goal did not create vast new technologies. To an overwhelming degree, as the stories by Kenneth F. Weaver and T.A. Heppenheimer point out, the Apollo program took what was on the shelf, then developed and refined it. There was no other way to build vehicles that would be so reliable as to approach perfection. Wholesale inventions are almost never reliable.

The story of the first moon landing is not just about the three men who made the voyage: it's also the story of the hundreds of thousands of people across the country who participated in Apollo. One of those participants, Don Wilhelms, describes how teams of geologists and engineers searched for the best possible site for Neil Armstrong to take his one small step.

At the time of the first moon landing, pundits called Apollo 11 a triumph for the "squares," meaning those scientists and technicians who worked with slide rules and wore crewcuts and polished their shoes. Americans never gave that observation much thought at the time, but it's a telling one because it hinted at just one of many societal divisions that had appeared in the turbulent postwar period of the '50s and '60s. A nation celebrating the Apollo 11 triumph in 1969 as a symbol of unity of purpose appears from our perspective here 20 years later to have been remarkably innocent and lacking in the skills of introspection. And as stirring as they were, the Apollo landings couldn't spare us the grimmer aspects of the '60s and '70s, as Charlotte Evans' piece shows.

Apollo 11 earned a permanent place in history as a momentous voyage. But the Apollo program should also be remembered for what was perhaps its most important attribute: it made us ask questions. It forced us to think.

—George C. Larson

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They called it quixotic. Impossible. It had never been done. Not even dared.

A 25,012-mile flight. Around the world. Nonstop. On a single load of fuel.

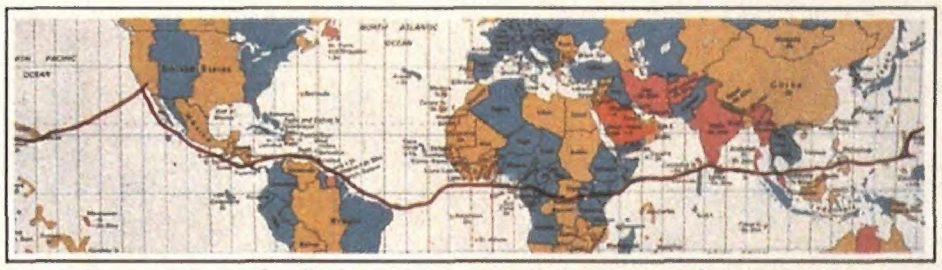
But Dick Rutan and Jeana Yeager dreamed it. And did it. On a mid-December morning, they took off into history. Nine days later, they landed in the record books.

It hadn't been easy. Not even for seasoned pilots who make a routine of record-breaking. Rutan, a retired Air Force lieutenant colonel, and Yeager, a drafting engineer, already held numerous world-distance and closed-circuit titles.

The revolutionary aircraft Voyager.

Voyager, Rolex, and one of the last great challenges of long-distance flight.

Record-breaking pilots Jeana Yeager and Dick Rutan.

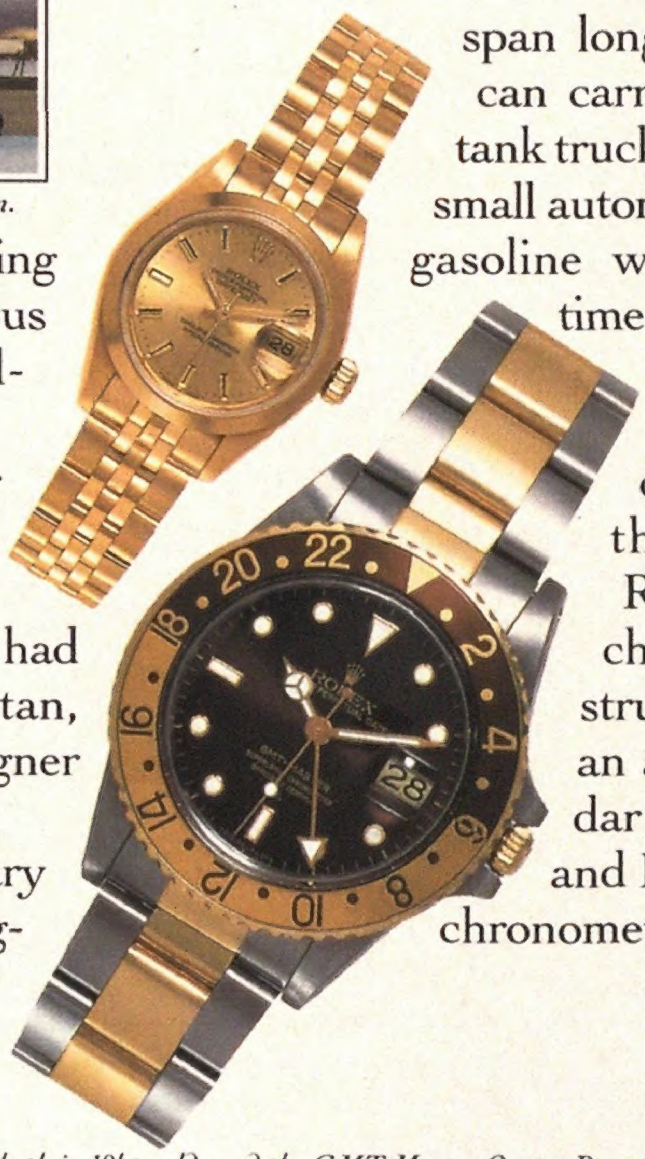


Voyager's irregular flight path, chosen to vector it around strong winds.

Yet much more than their exceptional personal skills was required to capture this laurel. A radically new plane had to be created by Burt Rutan, Dick's renowned aircraft-designer brother.

Voyager, the revolutionary craft he conceived, has a wing-span longer than a 727's and can carry as much fuel as a tank truck. Yet it's lighter than a small automobile. At takeoff, the gasoline weighed almost four times as much as the 2200-pound plane itself.

Because of the critical need to keep their aircraft light, Rutan and Yeager chose a minimum of instruments. Among them, an automatic pilot, a radar weather unit, and Rolex chronometers.



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Letters

Lost and Found

Toby Elster's "Lost in a Fighter" (Above & Beyond, April/May 1989) revived memories. I led Blue Flight on that trip, and am proud to recall that my six ships were among the 11 that made it down safely.

I probably had the most experience flying in China, having flown a 100-mission combat tour with the 75th squadron—the Tiger-Sharks—in 1944. On that flight we were a long way out of Kunming before it started getting chancy. After trying to contact the commander without success, I took it on myself to order my flight to stay together; apparently some of the others acted on my advice also.

While in the soup we had to take evasive action when two P-51s appeared on a 90-degree collision course, and we lost our number three element. They wound up landing at Nanking, as did three others. Our four were the first into Lungwha; Toby was the fifth, not fourth. I remember him coming in without a canopy.

The final score, I believe, was 11 planes and four pilots lost out of the original 22 that left Kunming. Considering the inexperience of most of the pilots, the incredible weather situation, and the gross errors in the maps, it could have been worse.

David H. Rust
Houston, Texas

Flying His Oats

As an overworked graduate student, the three-to-five-week period it takes me to complete an issue of *Air & Space* is one of the highlights of my harried existence. Imagine my excitement at reading Phil Cohan's account of the "Flyworm" aircraft ("As the Worm Turns," February/March 1989)—and my elation at learning that the first model had been constructed of simple household materials. I don't have time for things like this; I don't even like oatmeal, but spring break provided my golden opportunity. I slunk into my mother's kitchen, callously dumped her oatmeal into a plastic bag, and appropriated the cylindrical box for my experiments.

After completing my first model, I had little to show for my efforts. My oatmeal box "cyclone" had not even twirled into the next yard, much less "almost a block." A second, more desperate version followed, then a third; my spirits fell faster than my aircraft.

The contraption now awaits my verdict on the kitchen table. I understand the inventor's frustration, and I am considering dropping my own Flyworm into my equivalent of Mission Bay.

Mark Phillips
West Lafayette, Indiana

Military Intelligence

"Hell-Bent for Leather" (April/May 1989) reminded me of the kind of military logic that kept me from re-enlisting.

While stationed in North Carolina in the 1950s, both the enlisted flight crews and the officers were issued the famous G-1 Navy jacket. The jackets were considered flight gear and could only be worn at the hangar and while flying. However, when some new troops joined the squadron, foul-weather jackets (the standard work jacket permitted anywhere on the base) were in short supply. Those of us in flight crews had to turn ours over to the new men and work in our flight jackets.

Sure enough, station masters-at-arms (MAAs) started writing us up for being out of uniform. Our skipper tried to get the base commander to consider our jackets work clothes until more foul-weather jackets arrived, but had no luck. We could carry them under our arms (in freezing weather) but couldn't wear them. Some guys even tried wearing them under their work shirts. Eventually we just learned to outrun the MAAs to get to our barracks.

Michael Kolasa
Garfield, New Jersey

I was pleased to see "Hell-Bent for Leather," since painting flight jackets is one of my hobbies. While the article spoke of

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On top of that, there's our top: triple-layered, hand-fitted, with an electrically heated glass window.

Plus a 5-speed close ratio gearbox and a 1.8 liter fuel-injected engine.

So it's not just the lack of a roof that'll make your hair stand on end.

See your Volkswagen dealer.

And if after a test drive you decide you've got to have a sun like this, not to worry.

Chances are, you won't have to wait 9 months for delivery.

Cabriolet

For details on the 1989 Volkswagens call 1-800-444-VWUS.

the unusual resistance some have to flight jackets in general, there is also a history of objections to painted jackets.

Two incidents come to mind. One involved a crew member of an Eighth Air Force B-17 who bailed out over Germany; he was wearing an A-2 painted with the Air Force star and bar and the unfortunate phrase "Murder Inc." in four-inch-high Old English letters. The Nazi propaganda machine had a field day with this. A photo appeared in German newspapers with a caption denouncing the "luftgangsters" of the Army Air Forces. This incident—not, as some sources claim, one involving an Eighth Air Force B-26 also called "Murder Inc."—caused headquarters to order a review of all aircraft and jackets. As a result, politically sensitive names and paintings were changed or obliterated. Some group commanders included scantily clad women on the list of forbidden topics.

The "Murder Inc." jump may have triggered a second incident. The November 1944 issue of *Air Force* magazine included an item relaying a directive that the practice of painting field jackets and fatigues "be discontinued immediately," including "drawings, designs, mottoes, names—they're all out." This particular edict was largely ignored.

I hope that the present-day Air Force and Navy powers-that-be realize that personalized paintings can create the same unit pride and morale as the jackets themselves. Maybe paintings have already been banned again on the new jackets, but I hope not.

Michael J. Harney
Westford, Massachusetts

Same Genus, Different Species

A caption in "Hell-Bent for Leather" suggests that the approximately 300 volunteers known as the Flying Tigers or American Volunteer Group (AVG) were still flying in 1943. They were disbanded on July 4, 1942. Don Lopez was with the 23rd Fighter Group, which, along with the 14th Air Force, is sometimes confused with the AVG. Mr. Lopez makes this point when introduced to audiences as a member of the Flying Tigers.

Brad Smith
Berkeley, California

Editors' reply: Don Lopez's 23rd Fighter Group was called the Flying Tiger Fighter Group. The museum exhibit contains pieces from both the AVG and the 14th Air Force.

Speculating on Energia

I read with great interest the series of articles on the Soviet Energia booster and shuttle in the April/May 1989 issue. Obviously there is still a lot of puzzlement in the West about why the Soviets developed the system, especially since they already have reliable expendable spacecraft and boosters.

I suspect that when the Soviet shuttle was conceived it had two purposes: first, to recover some of their reconnaissance and intelligence satellites, which would otherwise have burned up on reentry, and second, to pluck Western satellites, particularly U.S. intelligence satellites, out of the sky. I suspect that despite the U.S. Space Command's satellite tracking, the Soviets could retrieve a derelict U.S. surveillance satellite without it being missed immediately, especially if Soviet satellites that were also to be recovered were launched in similar orbits to disguise the true intention of the mission.

Edwin Krampitz Jr.
Portsmouth, Virginia

Mikhail Chernyshov says that Energia has the capability to loft a 100-ton payload into low Earth orbit. Since he and the rest of the world (outside the United States) use the metric system, I am sure he was speaking of 100 *metric* tons (i.e., 220,000 pounds, which is the published capacity of the vehicle), not 100 U.S. tons (200,000 pounds). There is a difference of 20,000

pounds—roughly one-third the maximum payload weight the U.S. shuttle can send to low Earth orbit.

Deborah J. Neubek
Houston, Texas

Editors' reply: You're correct: the measurements given in Chernyshov's article were metric. The Energia can lift 100 metric tons—110 U.S. tons—to low Earth orbit. We regret the confusion.

Free the ISF

The detailed explanation of the wheelings and dealings behind the near-implementation of the Industrial Space Facility (ISF) ("Space Stations in Lobbyland," December 1988/January 1989) was informative, enlightening, and obviously the result of in-depth research. As a space commercialization advocate and one who has closely followed the quest for the ISF in various newspaper and magazine articles, I was surprised to see no reference to WESPACE (Westinghouse Electric Corporation), the prime contractor for Space Industries, Inc.

The ISF is a concept that will allow mankind to realize the benefits of low-gravity materials processing. The knowledge gained from its use should assist with the successful completion and operation of the space station. It should not be allowed to fall aside due to political maneuvering and perceived infringement on NASA's domain.

R. Steven Daugherty
North Huntington, Pennsylvania

Punching Out

I enjoyed Jay Stuller's "Chariots of Fire" (April/May 1989), especially since a Martin-Baker ejection seat saved my life in January 1961. I was flying an F-89 for Northrop on my way to release rocket-powered drones as targets for Nike missiles at White Sands, New Mexico. Overcast skies, freezing rain, and turbulent winds were forecast, and I made a radar-controlled climb-out from the airport. At an altitude of over 18,000 feet the aircraft started a violent and uncontrollable roll. My immediate thought was that one of the target drones had shaken off its wing mount because of turbulence and had struck an aileron. I pulled up the arm control to eject the canopy and squeezed the trigger to eject.

I regained consciousness the next morning and found that my right arm and right leg were in traction, my left arm was broken, and I had 10 other bone fractures, as well as a severed optic nerve. It was a small price to pay for my life. No parts of the airplane or the drones were recovered from the desert, although my protective headgear and its visor and oxygen mask were found.

Rod Close
Camano Island, Washington

Revenge of the Nerds

I was fascinated by the information in "Pilot Pep Rally" (Soundings, April/May 1989) on how the airlines hire pilots. According to the article, education is important (a master's degree helps) but not if it is excessive (a Ph.D. will hurt). Appear to be organized, neat, and punctual; if you're not, fake it. Pronounce the interviewers' names correctly, laugh at their jokes, say "yes sir" and "yes ma'am," and sprinkle their titles liberally throughout the conversations. I have been misinformed for many years: the airlines do not hire pilots, they hire obsequious nerds.

Jack Schoenberg
East Palatka, Florida

Air & Space/Smithsonian *welcomes comments from readers. Letters must be signed and may be edited for publication. Address letters to* Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.*

Col. Steve Canyon, USAF (Ret.)

"Caniff was a giant in his field," said Lucy Caswell, the curator at Ohio State University's Library for Communication and Graphic Arts. "He broadened the form and added stature it had not previously had. Little wonder that his characters began to take on the mantle of reality."

Caswell was lauding Milton Caniff, a 1930 Ohio State alumnus who garnered worldwide recognition for his colorful and dramatic comic strips. The occasion was the military retirement ceremony for Caniff's most popular character, U.S. Air Force colonel Stevenson Burton Canyon.

The handsome and somewhat beady-eyed Steve Canyon debuted in 1947 as a World War II B-25 pilot who left the U.S. Army Air Forces to launch a charter airline. His work took him to remote corners of a world populated by sneering villains, brave souls, and slinky damsels in flowing lingerie. In 1950 Canyon's creator put him back on active duty—this time with the Air Force Office of Special Investigations, which left him free to continue his international roamings and mysterious missions. The Steve Canyon strip ran until Caniff died last year at age 81.

Millions of readers eagerly followed Canyon's daily adventures, but the Air Force recruitment office was perhaps Canyon's biggest fan—hence the official retirement ceremony, presided over by Caswell and a larger-than-life cutout of Steve Canyon wearing a jumpsuit and parachute. Air Force officers, Canyon fans, reporters, and photographers lined an enormous table on which lay Canyon's 40-year military service record. It was the culmination of a project that began in 1950, when an airman asked Caniff to create a service record for Canyon to be used as an example in classes on initiating and maintaining that bible of personal military minutiae.

Caswell told her small audience that in 1973 Caniff had given many of his papers and drawings to the communications library and that artifacts and documents from today's ceremony would be added to the collection. She then introduced Colonel Edward White, a tall, graying, Canyonesque officer with a chest full of ribbons. "Instead of collecting baseball cards I eagerly followed the exploits and adventures of Steve Canyon," he said. "As a result, I was determined to make my career in the Air Force. Colonel Canyon was my hero. No telling how many other young men joined the Air Force because of Steve Canyon."

While the military contingent stood at attention, various certificates were presented and read, including one noting "the loyal and devoted service" of Canyon's patient wife, the former Summer Smith Olsen. First Lieutenant Lynn Ellen Bryant handed over a shadow box containing 13 medals and eight ribbons that the Air Force had bestowed in tribute to Canyon's exploits, and his military service record was also delivered to Caswell for permanent display in the library's Milton Caniff Research Room.

While the camera crews packed up, a few fans lingered to thumb through the service record. "Keeping up the record became a labor of love," Bryant told them. "It is extremely accurate in that it reflects each place he went and aircraft he flew. He had over 5,000 flight hours in a dozen aircraft types. He flew 150 combat hours and was wounded by flak over Europe in World War II. Here is his Purple Heart award."

When she came to the application for retirement someone pointed to the line that read "Signature of Applicant." In a faint, almost ethereal scrawl was the name Stevenson Canyon. Who had signed it?

"I did," Bryant confessed. "When we came to that part everybody else hesitated. I had worked with the record so long I decided to do it myself."

—Robert B. Parke

The Grand Tour

You're flying low and fast, skimming the floor of Valles Marineris, a vast canyon over 3,000 miles long. Suddenly you zoom past

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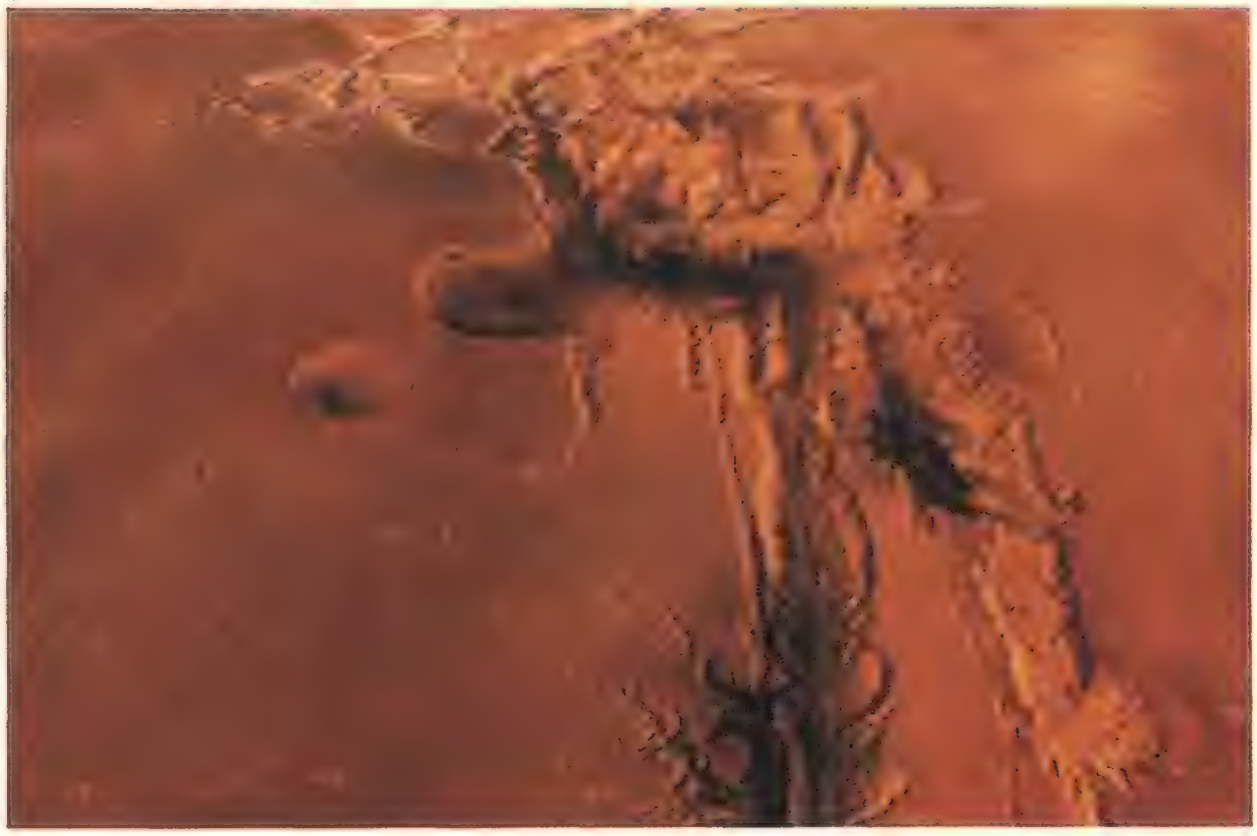


three giant volcanos—Arsia Mons, Ascraeus Mons, Pavonis Mons—each more than twice as tall as Mount Everest. Welcome to Mars, brought to you by the Jet Propulsion Laboratory in Pasadena, California.

Mars, the Movie is a breathtaking five-minute flight over an area of Mars the size of the continental United States, produced by image processing specialists Kevin Hussey, Tom Kelly, and Bob Mortensen. The film was made from a digital mosaic based on data from the two Viking Orbiters combined with U.S. Geological Survey contour maps of the planet (see "Putting Mars on the Map," October/November 1987).

Three other JPL movies were released last year. One provides an aerial tour of Los Angeles; another is a flight over the Uranian moon Miranda using imagery based on Voyager 2 photos. The third, *Earth, the Movie,* uses satellite data to show cloud formation and movement and demonstrates how Earth's topography influences its weather systems.

JPL's primary purpose in creating the films was to demonstrate a new tool that can assist in analyzing volumes of data. "We're moving towards the point when you can joystick through data like a video game," says JPL's Jeff Hall. The approach may be a windfall for planetary scientists in particular. "We can give them views they've never had before, since no spacecraft has actually done these flights," says Tom Kelly. No longer restricted to an overhead shot from a spacecraft, a researcher can now examine the side of a volcano or mountain. A video "pilot" can select any conceivable route of flight and a computer will display the images.

Mars, the Movie could help scientists determine where to set up a base on the Red Planet, but it also allows the public to explore a new world. Says JPL's Jurrie van der Woude, "It's like sitting in the cockpit of a helicopter and flying low over the surface like a bat out of hell."

A 17-minute VHS videotape containing all four planetary tours can be ordered from the Videotape Company, 10545 Burbank Boulevard, North Hollywood, CA, 91601.

—*Steve Nadis*

Update

V-22 Debut

The Bell-Boeing V-22 tilt-rotor made its first flight on March 19 at Arlington, Texas (Flights & Fancy, February/March 1989), after numerous postponements. The 12-minute flight, made nine months later than originally planned, was performed with the engine nacelles in the vertical position. A demonstration of airborne transition to the horizontal "aircraft" mode is slated for mid-May. However, defense secretary Richard Cheney recently proposed several budget cuts, among them the Marine Corps' V-22, which he says could be replaced with current transport helicopters.

Dodging Cosmic Bullets

On March 31 an astronomer at California's Palomar Observatory spotted a new fast-moving asteroid in the night sky. Although such discoveries are fairly routine, this one had whizzed within a half-million miles of Earth—just twice the moon's distance and the closest pass by a known comet or asteroid since 1937. The near-collision was doubly alarming because it occurred eight days before anyone spotted Asteroid 1989CF.

What exactly *could* we do if the collision of an asteroid or comet with Earth were imminent? With only a week's notice, not much. Astronomers could estimate the object's size and determine the approximate impact point, and an armada of aircraft would have to evacuate entire nations. Then we would simply wait.

An asteroid six miles across—about the largest known to cross Earth's orbit—would strike with the explosive energy of 100 trillion tons of TNT. If "ground zero" were on land, liquefied rock would spray out over thousands of square miles, the accompanying blast wave would incinerate vastly larger areas, and the planet might well be enveloped in a pall of ash and smoke that would linger for decades. An impact in the ocean would, in addition, trigger unimaginable tsunamis and taint rainwater with lethal concentrations of nitric acid, created when intense heat fuses atmospheric nitrogen and water. Scientists have invoked just such scenarios to explain why much of Earth's life abruptly disappeared 65 million years ago.

But with a little more warning, we might take the offensive. Take, for example, the case of the mile-wide asteroid Icarus, which in 1968 passed within 4.25 million miles of Earth. Hypothesizing that Icarus was destined to strike the Atlantic Ocean, a class of engineering students at the Massachusetts Institute of Technology concluded that the asteroid could indeed be avoided. In a frantic year-long scramble, they theorized, NASA would have to halt the Apollo program, tip six Saturn V rockets with 100-megaton warheads, then launch them at two-week intervals toward Icarus until one or more of the bombs shattered it into harmless fragments or diverted it off its collision course.

Recently, Edward Teller, former director of the Lawrence Livermore National Laboratory in California, suggested that technology derived from the Strategic Defense Initiative could be used to create an orbital early-warning system. Teller, a key proponent of SDI, believes that telescopic sentries could be built for less than $100 million. The space-based

system would detect incoming objects some six million times fainter than the human eye can see. This would provide up to a few weeks' notice of imminent collisions with objects like the 300-foot chunk of debris that devastated 2,500 square miles of Siberia in 1908.

However, Eugene Shoemaker, an Arizona astronomer who has been hunting down maverick solar system objects for decades, cautions that asteroids in established orbits, like Icarus, are not the problem. The real danger comes from undiscovered comets, which travel much faster, pack a much more energetic wallop, and might remain hidden in the sun's glare until just before striking Earth. And while comets are about 10 times less likely to hit our planet than asteroids, Shoemaker doubts that any warning system could completely protect us from being blindsided.

—*J. Kelly Beatty*

Update

Gripen's Gripes

The fly-by-wire software for the Swedish Gripen JAS 39 fighter, which was rewritten several times, has been targeted as the cause of the February 2 crash of the prototype ("Sweden's 'Flying Weapon,' " February/March 1988). Investigators say that crosswinds of up to 12 mph—"stronger than was built into the system"—coupled with "deficiencies [in] controlling the pitch axis at low speed" resulted in uncontrollable oscillations. The JAS 39 dragged a wing as it touched down and skidded off the runway when the landing gear collapsed. Deliveries of the fighter to the Swedish air force will now slip to 1993.

SLICK LAWSON

"Airport Sun Project," a Dale Eldred sculpture in the new Nashville International Airport terminal, inaugurates the city's Arts in the Airport program. The steel, glass, and grooved aluminum work diffracts the light that streams through the terminal's glass walls and scatters the colors of the spectrum throughout the interior. Eldred describes the airport as "a great sundial in which the sunlight is being sculpted." The work will remain in place through August.

Slayton's Starfire 1

A sounding rocket launch from White Sands Missile Range in southern New Mexico is usually attended by "six guys and a fire truck," as one old hand put it. But at 8:40 a.m. on March 29, there were more than 100 onlookers gathered when the voice over the loudspeaker said, "T minus two and counting." Half the crowd was wearing blue baseball caps emblazoned with "SSI"—for Space Services Inc., the Houston firm headed by former astronaut and NASA manager Deke Slayton. A new space race was about to be kicked off by the first U.S.-licensed commercial launch.

SSI's 52-foot-tall, two-stage Starfire 1 rocket, designed and assembled from off-the-shelf components in a mere seven months, was poised on Launch Complex 36, a mile from the bleachers. The Morton-Thiokol first-stage engine was loaded with juiced-up solid fuel that would get the rocket to altitude faster to provide nearly eight minutes of microgravity. The 650-pound payload consisted of six materials processing experiments produced by universities and private companies and organized by a University of Alabama at Huntsville consortium, one of 16 commercial development centers funded by NASA grants. SSI's launch was the first of 10 okayed for 1989 by the Department of Transportation in fulfillment of the Reagan administration policy of encouraging a private sector launch industry.

The previous day, representatives from NASA, the Department of Transportation, the university, the missile range, and SSI explained to the media their various roles in the mission. Uniforms and business suits prevailed, with the exception of Slayton's attire. In western-cut slacks, well-worn boots, and an open-necked shirt, the tanned, craggy-faced SSI president looked more like a character in *Lonesome Dove* than the shrewd head of a venture capital outfit that had beaten Martin Marietta, McDonnell Douglas, and General Dynamics out of the starting gate. SSI eventually expects to be making orbital launches—"where the big bucks are," says Starfire project manager Mark Daniels—and anticipates annual revenues of up to $500 million.

Slayton said that liftoff was a day ahead of schedule—probably a record in the launch business. He also said that financial details of the launch were proprietary but that it would be profitable and that the name of the game in this new trucking business was reliability. "If it's unreliable, it's uninsurable. And if it's uninsurable, it's probably unfinanceable." The Starfire 1 was about 97 percent reliable, he drawled, as opposed to the 90 percent reliability of most sounding rockets.

At T minus two minutes Slayton was in the windowless blockhouse a few feet from his rocket. The crowd in the bleachers fell silent at T minus 20 seconds, the countdown broadcast by a woman who was formerly a night manager at the local Wendy's. Then the first stage ignited and the rocket rose silently on a cloud of fire. Seconds later, just before the first stage dropped away, cheers from the bleachers coincided with the arrival of the basso roar of the first-stage engine.

An integrated security management system that can monitor and display security and fire alarms will help security forces operate more efficiently. The system, designed by Hughes Aircraft Company for General Motors' Regional Personnel Administration, will integrate new and existing systems in 180 GM plants throughout the United States. GM will establish 12 Regional Personnel Centers (RPCs) to serve the plant sites. Each RPC will perform central monitoring and control, rather than each plant site performing its own, as is presently the case. The new system has the potential to save GM millions of dollars each year. A similar Hughes-designed system is currently installed in the Smithsonian Institution in Washington, D.C.

A new antenna array will give the U.S. Navy F-14D Super Tomcat's radar superior electronic counter-countermeasure capabilities. The array, designed by Hughes for its APG-71 radar system, features a wide bandwidth and low sidelobes for reduced susceptibility to enemy jamming. In addition, flight tests have shown the low sidelobe characteristics are very effective in over-land operations. Used in conjunction with an integral guard channel, false alarms are virtually eliminated. The antenna array is being manufactured as a single assembly, lowering production costs while maintaining the tight tolerances specified for the system. The APG-71 is designed and built by Hughes under contract from Grumman Aerospace Corporation.

An innovative combination of thermal, radar, laser, and video sensors may accurately identify military targets on the battlefield. The combination, successfully demonstrated by Hughes in a joint venture with Texas Instruments, is called multi-sensor fusion. During operation, a computer combines digital terrain map information with data from a single package containing a thermal imager, radar system, laser rangefinder, and video camera to produce a "fused" target list. This process improves the probability of target identification and reduces the possibility of false identifications. The multiple sensor approach has applications in helicopter, fighter and tank operations.

A sensitive infrared detector lets scientists look back 15 billion years in time. The detector, designed and built by Hughes, is part of the United Kingdom Infrared Telescope (UKIRT) on Hawaii's 14,000-foot Mauna Kea volcano. The detector's focal plane array acts as extremely sensitive film in the camera system attached to the bottom of the telescope. It is able to penetrate clouds and space debris and senses infrared energy emitted by objects as long as 15 billion years ago, energy just now reaching Earth, providing a picture of what the universe was like during the early period of its formation.

Hughes Research Laboratories seeks highly-qualified scientists for advanced research in physics, chemistry and electronics. Disciplines include: Information sciences and artificial intelligence; space plasma sources; pulsed power switches; free electron lasers; electron beam testing; advanced IR detectors; liquid-crystal materials and displays; nonlinear optics and phase conjugation; computer architectures for image and signal processors; GaAs microwave devices and IC technology; and optoelectronic materials and devices. Send your resume to: Professional Staffing, Hughes Aircraft Company-Research Laboratories, Dept. S4, 3011 Malibu Canyon Road, Malibu, CA 90265. Equal opportunity employer. Proof of U.S. citizenship required for some positions.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES

Subsidiary of GM Hughes Electronics

The rocket's highest speed exceeded Mach 8—some 5,000 mph—and it reached apogee at 187 miles, 11 less than expected. About 15 minutes after liftoff it was announced that the payload had parachuted to earth 57 miles north and was lying safe and sound in the white gypsum sand.

—Jake Page

Update

Last Call for Solar Max

NASA is soliciting a final round of proposals on getting the last bits of data on solar flares from the Solar Maximum Mission satellite ("Here's Looking at You, Sol," October/November 1986). NASA estimates that Solar Max will reenter the atmosphere this November or December, almost a year earlier than was estimated when the agency announced last December that it had neither the money nor the shuttle mission slot to rescue it.

IKI

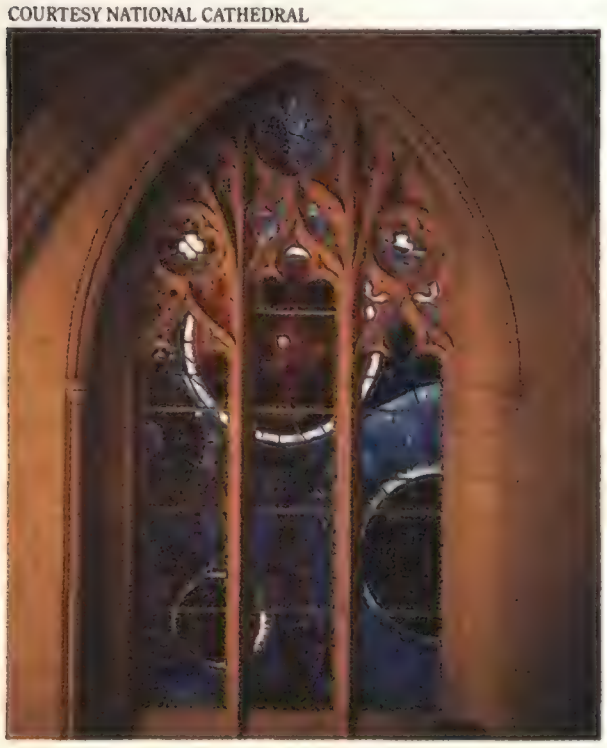
Late in February the Soviet probe Phobos 2, en route to the larger of Mars' two moons, relayed to Moscow's Space Research Institute photos of its target from (left to right) approximately 675, 275, and 200 miles. The sister ship of Phobos 1, which lost all power last September, the probe was scheduled to drop two landers onto Phobos early last April from an altitude of 165 feet. However, on March 27, as Phobos 2 photographed potential drop sites on the 14-mile-wide moon, transmissions became sporadic and then ceased altogether. Scientists will meet in mid-May to discuss launching a third Phobos probe in the early 1990s.

Splendor in the Glass

"Where's the moonrock?" asks the man in the bermuda shorts and Spuds McKenzie T-shirt. The docent sighs and points to a stained glass window at the end of the Washington Cathedral's south aisle. It's not the tourist's attire that irks her—it's his obliviousness to the surroundings.

With its intricate stone carvings and luminous stained glass windows, this 20th century limestone cathedral recalls Chartres, Strasbourg, and other architectural splendors of the Middle Ages. But one of the Washington Cathedral's stained glass panels has no equal: it is adorned with a lunar rock presented by the crew of Apollo 11.

COURTESY NATIONAL CATHEDRAL



Cathedrals through the centuries have depicted history in stained glass. The Space Window updates this tradition for the Washington Cathedral by reflecting its own era—the Space Age. Officially titled the Scientists and Technicians Window, the 18-foot-high, 10-foot-wide work commemorates the exploration of space.

Donated by former NASA director Thomas Paine, the Space Window was dedicated in 1974 on the fifth anniversary of the first lunar landing. During the ceremony, Neil Armstrong, Buzz Aldrin, and Michael Collins presented a chip of basalt to be sealed in nitrogen and affixed to the window. The 2.5-inch fragment, estimated to be 3.5 billion years old, was part of the 47 pounds of material retrieved from the Sea of Tranquility by Aldrin and Armstrong.

The moonrock no doubt accounts for a large share of the Space Window's popularity. But aesthetically the moonrock resembles "a black blob," in the words of one docent. According to Eugenia Parker, a stained glass specialist at the cathedral, some visitors consider the window too modern for its gothic-style setting.

Artist Rodney Winfield studied NASA photographs in an attempt "to feel the immensity of space." The result is a glass of the deepest blues that makes the window seem like a port in a spacecraft. Dark orbs are suspended in a sea of stars, and a thin white line suggests the trajectory of a solitary spaceship.

Traditionally, each panel in a stained glass window portrays an independent scene. But Winfield felt this would not do justice to the vastness of space. Instead, he used all of the panels to create one scene, which imparts a unique sense of depth.

Winfield, who now teaches at Maryville College in his hometown of St. Louis, Missouri, has fond memories of meeting the astronauts at the dedication ceremony. "I felt like I was shaking hands with Christopher Columbus," he says.

—David Savold

Update

CDSF: Not ASAP

The Commercially Developed Space Facility proposal ("Space Stations in Lobbyland," December 1988/January 1989) was shelved by a National Research Council committee last April. The committee claimed that the space shuttle, sounding rockets, and aircraft can accommodate materials processing experimentation until the NASA space station becomes operational in 1996. James Calaway, a founder of Space Industries, which proposed the CDSF, says his company will continue to market the facility in the United States, Europe, and Japan. "We'll be here for the haul," he says, noting that the NRC report did not rule out the eventual need for such a facility.

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Anniversaries . . .

1918
June 30 The *New York Times* publishes a medical report on the typical characteristics of a good pilot. "He who has led an outdoor life is most likely to pass the test, although there are exceptions. Splendid, powerfully built sportsmen have been known to fail altogether, and anemic, frail-looking youths of the student type have blossomed into brilliant pilots." One doctor stressed that "muscle sense counts a good deal in flying . . . . A pilot sensitive in the buttocks is quick to keep his machine on a level keel."

1921
July 3 Peltier Doisy, a veteran of the French air service, is frightened in the air by an earwig. Doisy, horrified by the sight of crawling insects, had taken off from Paris for a long flight when the earwig crept out at 4,000 feet. The *New York Times* reported that when Doisy "saw it grinning at him he gave a yell louder than any ever heard in the upper air." Hoping the insect would freeze to death, Doisy flew higher, but at 15,000 feet the bug was still alive. In desperation Doisy banked the airplane, knocking the insect out of his cockpit.

July 28 Concerned about fatalities caused by airplane acrobatics, the U.S. Department of War restricts Army aircraft from flying over populated areas and prohibits stunt-flying over spectators.

1923
June 6 Three young lions arrive in Paris via airmail from Brussels. A Belgian railway strike had left the lions' trainer with no other way of getting them home.

1924
July 12 A seaplane flown by a Captain Judson of the Police Reserve Aviation Unit terrorizes 350,000 sunbathers at New York's Coney Island. Hundreds dashed to the protection of a boardwalk when the airplane flew the length of the beach at an altitude of 25 feet. The pilot returned to repeat the performance, resulting in his dismissal from the police reserves.

1934
July 13 The International Sanitary Convention for Aerial Navigation issues sanitation guidelines to prevent the spread of disease by airplane. The convention requested airports to isolate diseased passengers and disinfect airplanes, as well as notify other airports of the presence of any infectious diseases.

1937
July 2 Amelia Earhart and navigator Fred Noonan disappear over the Pacific Ocean while attempting a round-the-world flight. One month earlier, they had begun the journey in a Lockheed Electra from Miami, Florida.

NASM

The disappearance of Amelia Earhart has never been conclusively explained.

1965
July 14 Mariner 4, the first successful Mars probe, begins a close-range flyby, returning 20 images of a heavily cratered Martian surface. Since 1877, astronomers thought they had observed unusually straight lines on the planet's surface and theorized that an intelligent civilization had built a canal irrigation system. Mariner 4 imagery and data revealed a planet with a very thin atmosphere and a weak magnetic field, but no signs of life.

1967
June 1 Two Sikorsky HH-3E Jolly Green Giants become the first helicopters to complete a nonstop transatlantic flight when they touch down at Le Bourget in Paris after a 31-hour journey. The

NASM

Used extensively for rescues in Vietnam, the HH-3E can carry up to 30 passengers.

helicopters took off from Brooklyn, New York, and performed nine midair refuelings as they battled strong headwinds and inclement weather. Igor Sikorsky, the 78-year-old founder of the company that manufactured the HH-3E, was present at the landing and called it "one of the finest days of my life."

1971
June 30 After spending 24 days in orbit aboard the Salyut 1 space station, three cosmonauts are killed when their Soyuz 11 space capsule undergoes rapid depressurization on its return to Earth. The decompression occurred when a cabin exhaust valve was jarred open as the Soyuz capsule separated from Salyut 1.

SOVFOTO

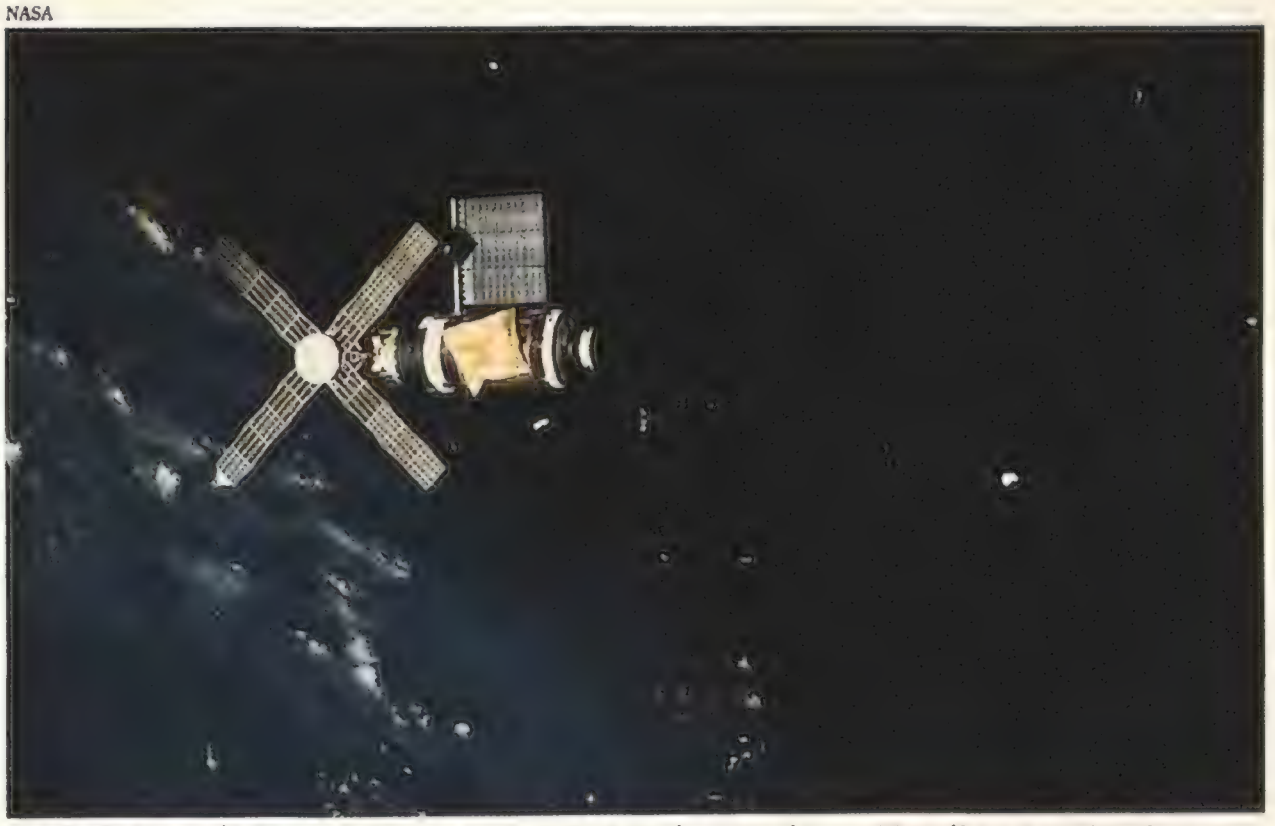
Sudden cabin depressurization killed the entire crew of Soyuz 11.

1979
July 11 After orbiting Earth 34,981 times, Skylab reenters the atmosphere, raining chunks of debris over western Australia. Uncertainty over where the space station would finally land caused worldwide fear in the months preceding its descent. At the U.S. embassy in New Delhi, India, 50 demonstrators demanded protection from Skylab's falling chunks; in Washington, D.C., computer experts set up Chicken Little Associates, which kept subscribers informed of Skylab's latest orbital path. As the space station neared Earth, NASA controllers sent it into a slow tumble, prolonging reentry enough for it to miss coming down over North America. Said one outraged Australian woman, "I think it stinks that they delayed the descent for 18 minutes so it missed them and hit us. I don't think our so-called American allies like us very much."

1985
June 3 The Soviet Antonov An-124 heavy-cargo transport makes its first appearance in the West, performing a demonstration flight at the Paris airshow. Designed to fly heavy equipment to remote oil fields, the An-124 has a fly-by-wire control system and can land on swamps and frozen lakes.

1988
June 14 An Air Force missile launch control crew receives a "missile away" launch signal from an MX missile on strategic alert at Warren Air Force Base in Wyoming. The 90-ton missile had not been launched, but an epoxy failure caused the MX to break away from its launch canister and fall seven inches inside the silo. The missile's first stage was totally destroyed, and replacement costs are expected to reach $4.8 million.

NASA



As Skylab's orbit decayed, fear mounted that falling debris would strike a populated area.

. . . and Events

June 2 & 3
Biplane Expo '89. Sponsored by the National Biplane Association. At Frank Phillips Field, Bartlesville, OK, (918) 742-7311.

June 3 & 4
Hamilton Field "Wings of Victory" Airshow. Over 100 World War II aircraft and the Coors Silver Bullet. At Hamilton Field, Novato, CA, (415) 382-1616.

Molson Canadian London International Air Show. This year's show commemorates the 40th anniversary of the founding of NATO. At the London, Ontario Airport in Canada, (519) 633-2546.

June 10
Experimental Aircraft Association Country Chicken Dinner Fly-in. Awards will be presented to the youngest and oldest pilots. At Nappanee Municipal Airport, Nappanee, IN, (219) 233-6466.

June 10 & 11
Michigan International Air Show. Canadian Snowbirds military jet team and the French Connection aerobatic team. At Kalamazoo County Airport, Kalamazoo, MI, (616) 381-8237.

June 17 & 18
Canadian Museum of Flight and Transportation's Annual Open House. Helicopter rides, vintage aircraft, automobiles, and fire engines. Surrey, British Columbia, Canada, (604) 531-2465.

June 21–25
Centennial Meeting of the Astronomical Society of the Pacific. Astronomers such as Carl Sagan will give lectures on supergiant black holes, the Hubble Space Telescope, and Supernova 1987A. At University of California, Berkeley, (415) 337-1100.

July 8 & 9
Central New York International Air Show. Aerobatics and World War II aircraft. At Oswego County Airport, Fulton, NY, (315) 349-3385.

July 14–16
Air and Space Weekend. Commemorates the 20th anniversary of Apollo 11. At California Museum of Science and Industry, Los Angeles, CA. Smithsonian National Associates, (202) 357-1350.

July 15–17
Apollo 11 20th Anniversary Celebration. Reunion of Apollo scientists and astronauts, including Neil Armstrong, Alan Shepard, Buzz Aldrin, and Michael Collins. A nightly pageant, "Footprints on the Moon," will reenact a lunar landing. At Space & Rocket Center, Huntsville, AL, (205) 837-3400.

For information on Apollo 11 anniversary events at Kennedy Space Center in Florida, call (407) 867-2468; and at Johnson Space Center in Houston, call (713) 483-5111.

July 20–23
Dayton Air and Trade Show. Aerospace trade exposition with performances by the Blue Angels and the Golden Knights. At Dayton International Airport, Vandalia, OH, (513) 898-5901.

July 28–August 3
Oshkosh '89, "From Jennies to Jets." Nearly 500 educational seminars and workshops on the latest aviation technology and daily airshows. At Wittman Airfield, Oshkosh, WI, (414) 426-4800.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Events will be listed as space allows.*

—Diane Tedeschi

The Making of *The Blue Planet*

NASA (2)

Astronaut turns cinematographer as John E. Blaha, Discovery*'s pilot, aims the IMAX camera through an overhead window.*

A shuttle's-eye view: the green around Andros Island delineates the Great Bahama Bank's shallow waters.

Last March, President Bush called to offer his congratulations to the astronauts aboard the space shuttle *Discovery.* After asking how they were feeling, he said, "And how's the camera? How's that IMAX camera going to be?"

"The IMAX camera has been working out really well, sir," replied Marine colonel and mission specialist Robert C. Springer. "In fact, we're getting a lot of great film that will help show a lot of people around the world how fragile the planet Earth is in this big vastness of space and maybe help everybody work to improve that."

Like the crew of *Discovery,* the president was caught up in the excitement of having the IMAX camera with 70mm film aboard the shuttle. While the mission's main goal was the deployment of a giant $100 million communications satellite, who could help thinking about the astronauts using the space shuttle as a tripod for panning camera shots of Earth? An erupting volcano in Japan, the eroding Ganges Plain, and the polluted air above Mexico City were some of the changing environments of our planet photographed by *Discovery*'s crew.

A problem with the electrical system had almost forced *Discovery* to return to Earth a day ahead of schedule, but the winged spaceship was able to complete its mission and orbit Earth 80 times at an altitude of 184 miles over the course of five days. When *Discovery* landed at Edwards Air Force Base in California on March 18, it brought back 14 rolls of film that will become part of the second feature-length film shot aboard the shuttle.

Tentatively titled *The Blue Planet,* this film is being directed and produced by Graeme Ferguson, president of Imax Systems Corporation and co-inventor of the 70mm large-screen format developed by the Toronto-based company. NASA, Lockheed Corporation, and the Museum are also cooperating in the production.

Imax Systems is responsible for two previous space shuttle films: *Hail Columbia* in 1981 and *The Dream Is Alive* in 1984. The latter was the first to feature footage shot from the shuttle, and it has proved to be enormously popular. Filmed prior to the *Challenger* accident, the 37-minute film includes footage from three shuttle missions (41-C, 41-D, and 41-G) and features an overview of shuttle operations. It is narrated by Walter Cronkite.

While inspired by its predecessor, the new film will not be a "Son of *The Dream Is Alive.*" Instead, *The Blue Planet* will spend less time on shuttle operations and more on views of our planet. Its theme will be global change. Writer and film editor Toni Myers says the decision to focus on Earth grew out of the tremendous audience response to the views of our world in *The Dream Is Alive.*

Each member of the *Discovery* crew was trained to operate the IMAX camera, which weighs about 80 pounds. The zero gravity of space considerably lightens the load. *Discovery*'s mission commander, Navy captain Michael L. Coats, had shot some of the footage in *The Dream Is Alive* and was already "a very talented cinematographer," according to Myers.

The astronauts also familiarized themselves with a storyboard—a pictorial equivalent of a script. Every orbit had a wish list of camera opportunities. NASA officials and other advisors helped select sites to be photographed.

"Astronauts have a unique capability of photographing dynamic global change," says NASA's Charles Wood, manager of the space shuttle earth observation office, which worked closely with Imax Systems. He believes the IMAX film offers a coordinated way of monitoring change in the global environment. Astronauts can react at will—change a lens or improve a camera angle—unlike remote sensing satellites.

Granville Pennington, a flight director at the Johnson Space Center, described the *Discovery* crew and ground personnel as "extremely pleased" with the camera work. He was especially thrilled about a shot that involved a timed rotation of the orbiter to take a horizon-to-horizon scan "from starfield to oceans to land masses and back to starfield." The principal cameramen were Air Force colonel John E. Blaha, the mission pilot, and Marine colonel James F. Buchli, a mission specialist. Blaha proved especially handy by fixing a malfunctioning belt in the camera. Myers was enthusiastic in her praise for all the astronauts: "The crew worked incredibly hard."

The Blue Planet will also include footage from upcoming shuttle mission STS-32. The IMAX camera is scheduled to be aboard *Columbia* in November when the crew will attempt to photograph the large

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weather systems that appear in the Atlantic during that time of the year. And the film producers still hope to get footage of the thousands of fires from slash-and-burn farming in the Amazon rainforest. South America was covered by clouds during the recent *Discovery* mission.

The Blue Planet is scheduled to premiere in the fall of 1990 at the Museum. President Bush has already thanked *Discovery*'s budding filmmakers in advance for the new perspectives on our planet: "I think a lot of people will see just from your important mission the contribution space exploration can make to the world environment. So we're grateful."

—David Savold

Programmed to Win

Museum visitors tend to favor displays with live action: push a button and watch something happen. Better still, add a computer and watch a whole series of events happen.

"Beyond the Limits: Flight Enters the Computer Age," the Museum's newest gallery, has been designed to offer visitors hands-on experiences with computers simulating real aerospace engineering principles. The gallery's curators had originally worried that accurate, thorough depictions would take too much time, which would be a problem with the high rate of visitor attendance at the Museum. Then they came up with an idea: at thousands of colleges and universities, students design computer software every day in the course of their work. Why not invite them to try to solve the problem?

Together with Apple Computer, Inc. of Cupertino, California, the Museum formulated a contest. Entrants were asked to develop routines that would illustrate clearly and accurately how computers are used in any aspect of aerospace engineering. The tricky part: the demonstrations should last for no more than two minutes.

Three Caltech students took top honors with a computer program called "Multi-Stage Rocket Design." Pierce T. Wetter III, a junior in electrical engineering, and two physics majors—Mike Meckler, a sophomore, and Glenn C. Smith, a junior—shared the glory, and with the grand prize award of ten Apple Macintosh II computers for the university went a promise to include the winning program in the new gallery.

The Caltech program allows visitors to simulate the designing and test firing of a rocket. Using the computer, a visitor can specify the number of stages (up to five) the rocket will employ, the type of fuel (liquid or solid), and the amount of thrust allocated to each stage. The program simulates the launch of the rocket and calculates its final altitude, comparing the result to previous visitors' designs.

Museum curator Paul Ceruzzi, delighted with the results, said the students were, in some respects, "ahead of us [in] breaking new ground . . . exploring new themes and new ways of presenting exhibit material."

—George C. Larson

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Apollo 11 Anniversary Celebration A ceremony co-sponsored by NASA will be held on the steps of the Museum facing the Mall on Thursday, July 20, from 11 to 11:45 a.m. Participants will include Apollo 11 astronauts Neil Armstrong, Buzz Aldrin, and Michael Collins. The Museum will remain open that evening until 1:30 a.m. for a Lunar Landing Party. Free films, telescope viewings, tours, demonstrations, and other space-related activities will be offered. The original 1969 network television coverage of the first walk on the moon will be featured on closed-circuit monitors. The Museum's restaurant and gift shops will be open late that evening.

New Exhibit "Aeropittura Futurista: Images of Flight in Italian Art from 1913 to 1942." Italian futurism, the first modern art movement to embrace technology as subject matter. Opens June 16 in the Museum's Flight and the Arts Gallery. Through mid-September.

Summer Concert Series Free concerts on the West Terrace featuring music ensembles of the U.S. armed forces. On selected weekdays at noon or 6 p.m.

June 3 Monthly Sky Lecture: "Astronomy for the Fun of It." Geoffrey Chester, NASM. Following the lecture, there will be a viewing of the sun by telescope, weather permitting. Einstein Planetarium, 9:30 a.m.

June 7 Exploring Space Lecture Series: Other Suns, Other Worlds—"The Supernova Story." Laurence A. Marschall, professor of physics, Gettysburg College. Einstein Planetarium, 7:30 p.m.

July 1 Monthly Sky Lecture: Speaker to be announced. Einstein Planetarium, 9:30 a.m.

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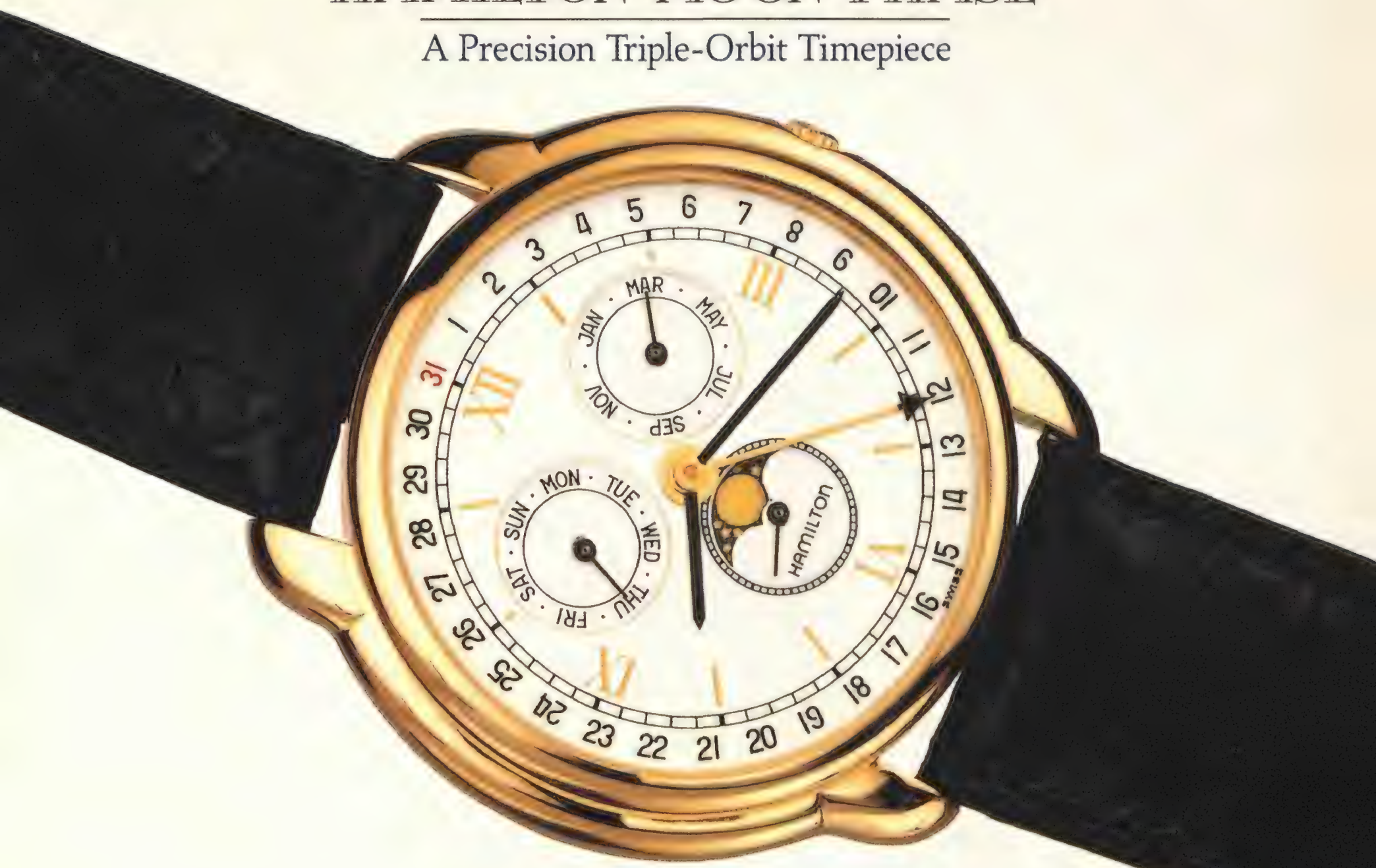

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Snapshot

It was February 1972, and the northern hemisphere was struggling through winter. I had managed to talk my way into bringing a Royal Air Force Vulcan bomber south of the equator for a week or two of summer sunshine, and during part of the trip we would represent the RAF at New Zealand's annual airshow.

We had worked our way eastward, island-hopping from our base in Cyprus in easy stages. Our landing at Masirah, off Oman's barren coast, had been delayed—camels on the runway. Giant fruit bats had forced us to take evasive action on the approach to Gan in the Maldive Islands.

After an evening spent sampling the more sophisticated hazards of Singapore nightlife, we made our way to Darwin, Australia, where a Niagara of steamy rain had welcomed us, along with the promise of outsized cockroaches for company. Declining invitations from the locals, we had aquaplaned out of there in haste to take a breather in the friendlier air of Sydney. After a day or so, we launched ourselves across the Tasman Sea to New Zealand, where we prepared to do our show for the Kiwis.

As American audiences know, the Vulcan was always in demand as a display aircraft. The huge delta was astonishingly agile, particularly at low altitudes. Designed originally to deliver nuclear weapons from above 50,000 feet, it was blessed with generous quantities of wing area and thrust, both of which came in very handy during a low-level show. These dual virtues allowed a Vulcan to be displayed at between 140 and 150 knots—a very low airspeed for a large, heavy airplane. Its turning ability at these speeds made for a very tight show, and resulted in an impressive amount of noise—lots of power from the four Rolls-Royce Olympus 301s was needed when maneuvering energetically so close to the stall.

It never failed to surprise me that the members of my crew were prepared to put up with such behavior. The crew compartment of a Vulcan was, at best, uncomfortable. It was extremely small, and the five crew members it held could rightly compare themselves to sardines. The two pilots were the only sardines to enjoy the privileges of ejection seats and windows. The "rear crew" had neither blessing. They sat in a black hole behind and below the pilots, and, what is more, they faced the rear. I have reason to believe that they prayed a lot.

Certainly our rear crew members were earning their trip to the antipodes, because

RAF

it had become obvious since our arrival that we were expected to do a lot more display flying than we had originally planned. After our welcome to the North Island by the Royal New Zealand Air Force, we had been invited to show off the Vulcan all over New Zealand in the days before the show. We had agreed and were now engaged in some impromptu touring.

The day was bright blue and the air gin-clear. We had just paid our respects to Invercargill at the southern end of the South Island, and stunning scenery was unrolling before us as we cruised gently northward at 250 feet toward Queenstown, which was where we next intended to shatter the peace. The white dots of sheep were scattered everywhere like confetti, and in the distance we could see the mountain range known as the Remarkables. We passed over the little town of Lumsden, and a single-track railway line joined us. I began to follow it as it meandered through a broad valley.

We swept around to the northeast as the valley curved and, just for an instant, there it was: a shiny locomotive hauling a few carriages and trailing—smoke? By the time it registered on the eye, we had rushed ahead and it was gone. "Did you see that?" I asked the copilot.

"Sorry, boss. I had my head down doing a fuel check. See what?" Copilots did not have time to look out the window.

"We'll go back," I said, winding on 60-odd degrees of port bank. "I wouldn't want you to feel deprived."

I had not imagined it. There it was again, and this time I could take it all in. At the head of the train was a gleaming black monster, smoke billowing from its stack and pistons flashing in the sun. It had a cowcatcher and a headlight and a big brass bell. The carriages were brightly painted and brass-railed, and each had its own name. "Stand by with the downward-facing cameras," I instructed the navigators. "We have got to have a picture of this."

A simple thing, you might think, photographing a train from a Vulcan on a sunny day. Not so. Every time we passed over him, the engine driver seemed to take some delight in diving into trees or hiding in a gully. Five times we went around before I caught him in the open. By now I was grimly determined. I had slowed to 170 knots, and I was as low as I thought sensible as I came at him head on. The cameras clicked. "Got him!" I yelled in triumph as I opened up to full power and pulled away, leaving heavy black trails in the crystal air.

Minutes later the waters of Lake Wakatipu lay smooth beneath us; we had a few moments to force our minds back to the job at hand before doing our thing for Queenstown. The tourists in that lovely town having been duly startled, we pulled up to the west, over the soaring peaks and rushing waters of Fiordland National Park.

Our route back to Ohakea lay along the crest of the Southern Alps. Flying northeast, we weaved between glaring white peaks and over glittering lakes. Glaciers swirling like cloaks from its shoulders, Mount Cook stood supreme, a giant among giants. Beholding such a spectacle, our senses were full, our day complete. Nothing else of note could happen now. Or so we thought.

Half an hour later we were on the ground at Ohakea, and not too long after that we were showered and shaved and ready to tell our tales. In the bar at the officers' mess we regaled our hosts with stories of our wondrous doings while they kept our glasses filled with good Kiwi beer. None of them seemed to know anything about our phantom train, though, and I began to think that we might have strayed into the Twilight Zone. Perhaps there would be nothing on the film.

"Telegram for Wing Commander Dick," called an orderly officer weaving through the throng. He presented me with a piece of paper, and I read: "For the Royal Air Force Vulcan crew from the driver of the Kingston Flyer. You look quite beautiful—but you have a dirty exhaust and a fly spot on the left wing. Signed, Russell Glendinning."

Now *there's* a man with an eye for detail and a passion for perfection. The Kingston Flyer does him credit. Go see it if you are ever near Queenstown, but don't believe the driver when he tells you how low the Vulcan was.

—Air Vice Marshal Ron Dick
Royal Air Force (Ret.)

Measuring Up

My main concern upon boarding an airliner is not with the craft's age, or terrorists, or midair collisions. It is that whoever sits in front of me will be a sleeper—the sort who immediately reclines the seat as far as it will go and conks out until we're about to land. Because my knees crowd this seat even when it's upright, any reclining by its occupant grinds my kneecaps into powder.

The seats were presumably designed to accommodate some ideal or at least average human form, one to which I most decidedly do not conform. The art scholar Kenneth Clark often dwelt on the ideal human form and formulated various parameters based on his studies of Greek statuary. One was that lines drawn between the navel and nipples should describe an equilateral triangle. I fail in this and all other parameters.

Clark was practicing the liberal arts version of anthropometry, the detailed measurement of human physiques. It is traditionally used by anthropologists to get a bead on the physical differences between, say, Hottentots and Eskimos. It is also a useful science for designers studying the interface between man and machine, and about 20 years ago it was used to design better seats for flight attendants.

Anthropometry of Airline Stewardesses, a study commissioned by the Federal Aviation Administration, noted that while much work had gone into the design of the airline cockpit, such was not the case with stewardess accommodations. The seats were often near the galley, where equipment could be dislodged in a mishap; they occasionally folded up while occupied; they had ill-fitting restraints or none at all; and they were usually too low for the occupant to see into the cabin or outside the aircraft. In general, it was concluded, stewardesses were at great risk during a takeoff or landing accident.

Thus in 1971 some 400 stewardess trainees at the American Airlines academy were systematically measured, from forehead width to ankle circumference, by two anthropometrists and three assistants. Senator William Proxmire of Wisconsin conferred on the study one of his infamous Golden Fleece awards for wasted government dollars, but it did result in better seat design for the cabin crew.

I have never found an equivalent study of the majority of people on airliners—the passengers. Unless their design was pure whimsy, the seat designers must have had some average figure in mind that represented the ideal passenger. The last time I flew, I did an anthropometric study of my seat and arrived at the following specifications for that ideal figure.

1) The back of the head should meet the top of the seat at approximately eye level for maximum comfort and proper support of the neck vertebrae.

2) The diameter of the thigh can equal but not exceed the height of the armrest. This restriction permits the seatback tray to lie flat when in use.

3) The elbows should be at the same level as the top of the thigh to enable the forearms to lie flat on the armrests.

4) The upper back should be narrower than the seat back, for obvious reasons.

5) Because the curve of the human back does not match the concavity of the seat, the passenger will put one of those white pillows from the overhead bins behind the lower back. To accommodate the pillow while preventing the kneecaps from grazing the seat in front of the passenger, the maximum distance from coccyx to kneecap must be decreased by about four inches.

My study has determined that the ideal passenger is roughly the same height as the average stewardess of 1971, but there the resemblance stops. The ideal passenger must have thick, short thighs and exceptionally long upper arms. The upper back is absurdly narrow in proportion to the broad hips. This is not at all what Clark had in mind—the chest is far too slender to permit anything like an equilateral triangle—and is nothing that Praxiteles would have given a second glance.

But evolution marches on. Whenever I spot people of these dimensions at an airport, I will be pleased to inform them that they have achieved the Ideal Passenger Form.

—Jake Page

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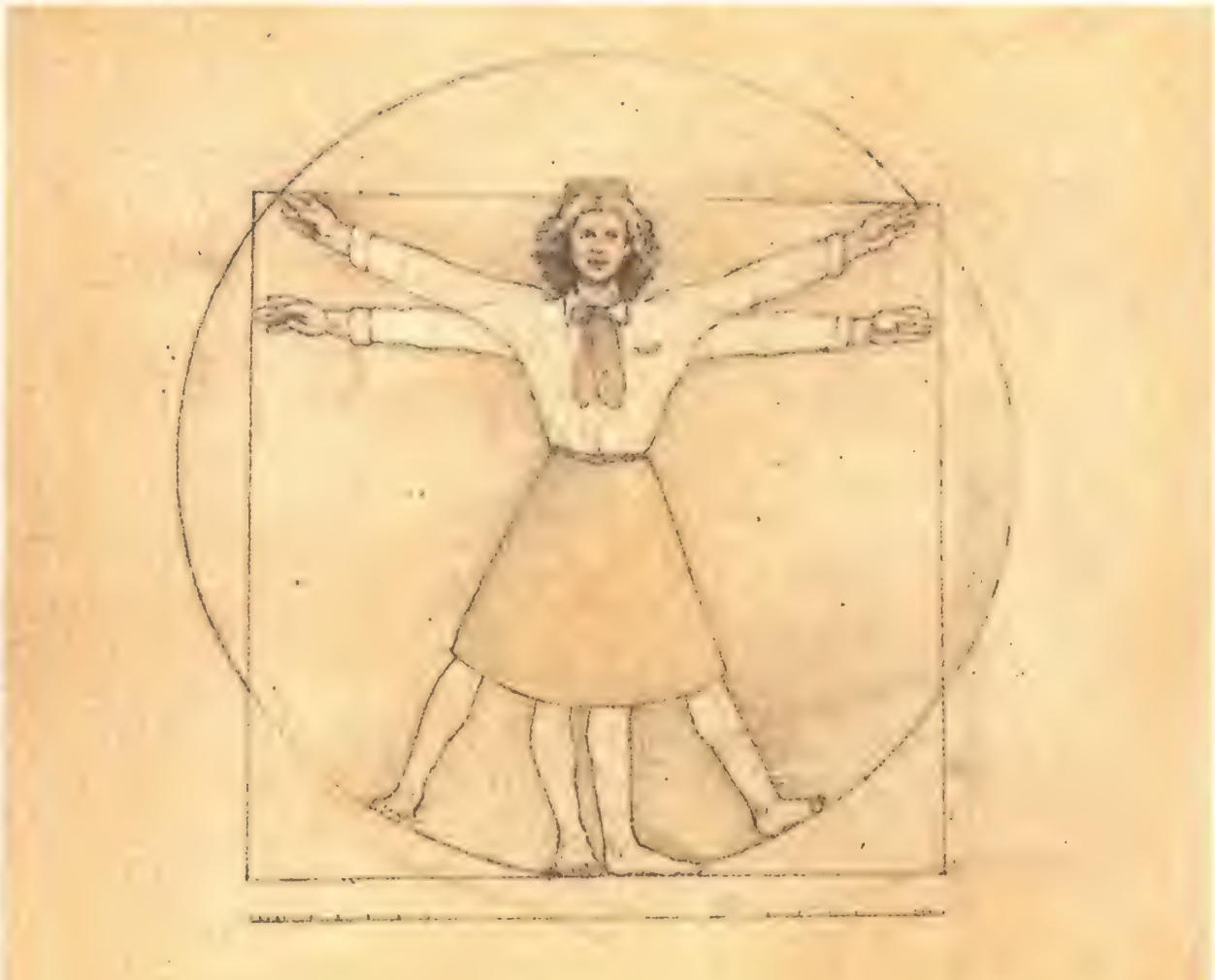

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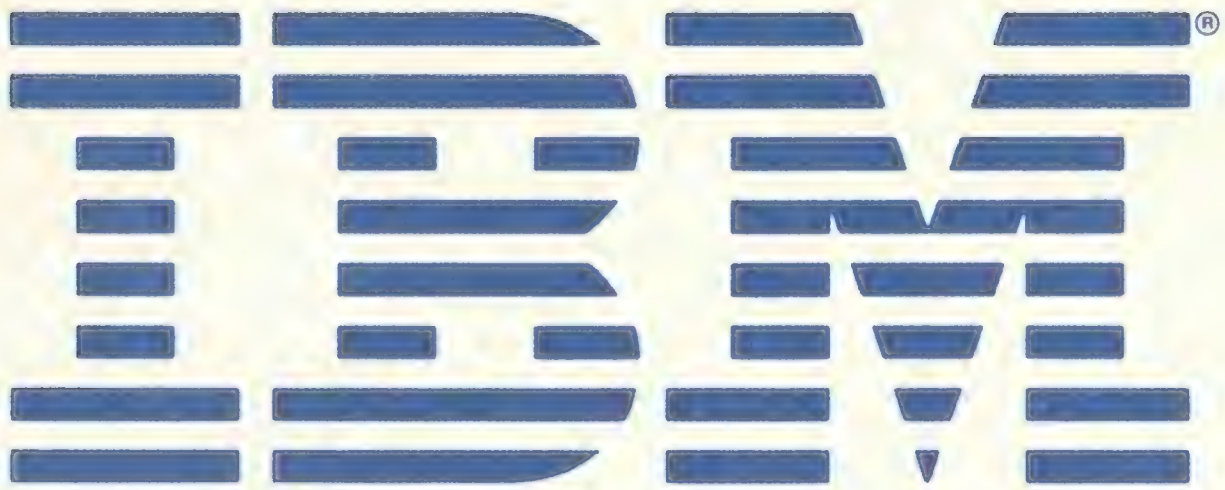
After all, if Man can land an Eagle on the moon, he can surely keep them landing on the earth.

PHILLIPS 66

For more information, contact the George Miksch Sutton Avian Research Center Inc., P.O. Box 2007, Bartlesville, OK 74005, (918) 336-7778.



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We are honored to have received these awards and are proud of all the dedicated people at IBM who helped make it possible. Still, a reputation for quality isn't something you can rest on. That's why we keep working hard to earn our stripes.

. . . I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the Earth. No single space project in this period will be more impressive to mankind or more important for the long-range exploration of space. And none will be so difficult or expensive to accomplish . . . .

This decision demands a major national commitment of scientific and technical manpower, materials, and facilities, and the possibility of their diversion from other important activities where they are already thinly spread. It means a degree of dedication, organization, and discipline which have not always characterized our research and development efforts. It means we cannot afford undue work stoppages, inflated costs of materials or talent, wasteful interagency rivalries, or a high turnover of key personnel.

New objectives and new money cannot solve these problems. They could, in fact, aggravate them further—unless every scientist, every engineer, every serviceman, every technician, contractor, and civil servant gives his personal pledge that this nation will move forward, with the full speed of freedom, in the exciting adventure of space.

—John F. Kennedy, May 25, 1961

AIR&SPACE
Smithsonian

A GREAT NEW ENTERPRISE

After the twin shocks of Sputnik and Gagarin, Americans' confidence needed a boost. Politicians gave them the moon.

by Wayne Biddle *Illustrations by Paul Salmon*

The day man reached the moon has receded enough in time that the explorers and their machines have begun to seem a bit remote. They do not look as quaint as the Wright brothers, but the drift is already noticeable. Once the quintessence of the future, Project Apollo has become another archetype of the American past.

Something greater than a simple 20-year expanse separates the Apollo era from today. The fabric of American life has changed since then, along with the institutions that color it. Tracing the history of Apollo thus means examining the unique set of political and economic forces that shaped the United States and its institutions in the 1960s and made the moon the place to be.

Visiting the moon became a top government priority eight years before the first landing, when President Kennedy told Congress on May 25, 1961, that achievement in space was part of "the battle that is going on around the world between freedom and tyranny." He did not sell the "great new American enterprise" as a scientific mission but as a way of influencing "the minds of men everywhere who are attempting to make a determination of which road they should take"—namely, capitalism or communism. From the start, Apollo was a spectacular gambit in the Cold War, an essential test of the American way of life.

"Kennedy wasn't terribly excited about doing it—something not generally understood today," recalls Jerome Wiesner, J.F.K.'s chief science advisor. "But he was faced with a dilemma. You could do nothing new, and remain behind the Russians indefinitely. Or you could quit the space race, which wasn't a real option. From a purely political point of view, the United States had to do something that would ultimately put the relative technological capabilities back in perspective. The pressure on him was enormous from the public. He used to press me, saying, 'Can't you find something to do here on Earth that would use the money more effectively?' And I said, 'Not with the same political effect.' "

The young president and his charismatic approach to politics stood in exhilarating contrast to the Eisenhower style, but Kennedy's decision would have sounded foolish in the absence of any prior planning. Although Eisenhower had never accepted the necessity

mit itself, to achieving the goal, before this decade
the moon and returning him safely to the earth."

of a big-ticket space program for national prestige, the 1957 launch of Sputnik, the world's first artificial satellite, and the subsequent waves of fear and shock it set off in the American public had forced his hand. The following year Eisenhower created a civilian space agency, the National Aeronautics and Space Administration, and opened the highest levels of federal policymaking to scientists and engineers. Project Mercury, America's first manned spaceflight program, was soon under way in a wave of patriotic fervor.

But with only minimal support from Eisenhower, nothing as exotic as a trip to the moon could emerge from backstage dreaming. "At that time, a lunar mission looked pretty wild—it was far down on the list of ordered accomplishments," recalls Edward Purcell, a Nobel laureate physicist who served on various space advisory panels during the Eisenhower and Kennedy administrations. "In the early days, one problem was that people needed to have even something as simple as satellites explained to them. No matter how high the bureaucrat might be in Washington, he didn't understand what kept them up."

"Eisenhower was just not interested" in a lunar mission, remembers Robert Gilruth, director of Project Mercury and of the Manned Spacecraft Center in Houston from 1961 to 1972. "He was an old man, and he didn't want any part of it. So there wasn't any real money spent on it. But there were a few people who were off by themselves thinking about what it would really take."

Indeed, Gilruth was one of the principal thinkers. By the time Kennedy moved into the White House, NASA had already picked landing on the moon as its long-range goal and determined that such a mission would at least require no fundamental breakthroughs. Kennedy himself had little knowledge of space, but he had campaigned on the supposed existence of a "space gap" and a "missile gap" and had chosen a powerful advocate of big space projects, Texan Lyndon Johnson, as his vice president.

During his first few months in office, sobered by foreign policy difficulties in Laos and Cuba and the 1960-61 economic recession, Kennedy was as cautious as Eisenhower had been about a sharp acceleration of the nation's space program. The most he would commit was a $125 million increase over Eisenhower's last NASA budget recommendation of $1.11 billion, mostly for development of heavy-lift booster technology that might also be of use to the military. Yet the pieces were in place for a major space initiative—what was needed now was a real push to give it momentum.

It came on April 12, 1961, when Yuri Gagarin orbited Earth in a five-ton capsule, becoming the first man in space. Americans had taken for granted that one of the seven Mercury astronauts—who had attained nearly god-like status in American mass culture—would make it there first. But once again the Soviets had taken the lead.

> Kennedy "wanted the United States to be number one, and it wasn't," Gilruth says. "It was just as simple as that."

As Sputnik had been four years earlier, the Soviet feat was far more a political jolt than a technical victory. Scientists and government officials knew that Vostok 1 did not represent a serious gap between American and Soviet prowess, though the Soviet boosters' capability to handle greater loads than the United States' was worrisome. But the public and much of Congress were shocked, their fears fanned by Cold War press rhetoric such as the *New York Times'* suggestion that Vostok might cause "Western governments to make concessions on the great world issues of the present day." Kennedy could not tolerate this and soon made his grand move.

Looking back on the times, James Webb, hard-driving NASA administrator from 1961 to 1968, offers a broad context: "Having made the atom bomb and used it in World War II, and having felt that this would be an umbrella over the development of the Earth based on market trade and not communistic government, the senior thinkers in this country were really shocked when they saw the Russians doing space probes before we could .... Anytime you can launch a rocket and have it orbit the Earth, you've got a powerful military weapon, even if you're not building it as such. Kennedy needed Apollo because he was being hammered over the Bay of Pigs, he was being charged by the opposition that he had no real programs to carry out his promises, and that he didn't really understand the complications of international diplomacy."

"He wanted the United States to be number one, and it wasn't," Robert Gilruth says. "It was just as simple as that. Of course, he was a young man."

Once the President had staked the nation's reputation on reaching the moon by the end of the decade, NASA officials who had campaigned for years for such a mission were suddenly faced with the boggling problems of actually meeting his all-or-nothing challenge.

"They didn't have the faintest idea how to do it," remarks Willis Shapley, who reviewed NASA's programs for the Bureau of the Budget until 1965 and then served as associate deputy administrator of NASA until 1975. "Webb was very lukewarm when he first came in—he had worked a lot for the government and knew what a billion dollars was."

Congress, for its part, helped ease the pain by opening the Treasury coffers to a degree that had never been seen for a single-purpose, non-military venture. The space agency's budget soared from $523.6 million in 1960 to an Apollo-era high of $5.25 billion in 1965, an increase of more than 1,000 percent. Between 1961 and 1967, Congress cut the administration's NASA funding request by more than 10 percent only once: an across-the-board reduction in 1964 of 10.7 percent that did not eliminate any programs.

"We had a most unusual kind of economic situation, one that is in particular contrast with the situation today," observes recently retired Senator William Proxmire, a longtime watchdog of the NASA budget. "We had a very big increase in government revenues because the economy was doing well. And there was a feeling that we wanted to maintain those revenues and not cut taxes. It was argued that what we should do, in order not to slow the economy by running surpluses, was give a substantial amount back through revenue sharing.

Therefore there was funding available to go ahead with this exciting activity in space."

With a blank check and White House blessings, Webb and his top NASA managers proceeded to forge not just a moonship but an earthbound technological empire to support it. "We were getting a lot of money—to build facilities, to build the biggest machines the human race had ever built, to bring universities into a different relationship with the national government—and that obviously required a lot of things different than had gone on in ordinary procurement," Webb says. "It wasn't possible, in my view, to sit down and say, 'Here's a standard form of organization—personnel department, operations department, supply department, and so forth.' We had to get a development and testing philosophy going in a hurry, based on the latest science in this field. We were building a capability for the entire United States."

By the end of 1961, Webb—who was not an engineer but a lawyer and businessman who had directed the Bureau of the Budget under President Truman—had reorganized NASA so that what had originally been a widely scattered group of semi-independent research fiefdoms all reported directly to headquarters in Washington. Industry contracts were quickly awarded for the Apollo booster, command section, and guidance system (NASA-sponsored feasibility studies had been under way in the aerospace industry since the fall of 1960, with hopeful contractors spending millions of their own above what the space agency paid them). Webb and his closest deputies decided the biggest contracts personally, wielding enormous power in a fashion that would be politically impossible today. Still, the question of just how to get to the moon—whether by direct ascent or some indirect path involving an Earth or lunar orbital rendezvous—went unanswered.

The configuration of the entire rocket—and, of course, the ultimate disposition of billions of dollars—depended upon the choice of a flight scheme. This issue ignited fierce rivalries throughout the space establishment, most of all between NASA and the academic science community. Although the obscure but elegant lunar

5 4 3

UNITED STATES

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The South Bend Tribune.

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The South

MOON CRA

Marines Repel

orbital rendezvous (LOR) method, in which a spacecraft would orbit the moon while a separate vehicle would travel to and from its surface, was finally accepted by all in late 1962, the principal adversaries still bear battle scars.

"The argument essentially was that the lunar orbit rendezvous approach made sense for going to the moon but didn't make much sense for other kinds of space activity," says Franklin Long, a Cornell chemist who chaired a space vehicle study panel for the President's Science Advisory Committee. "A takeoff from Earth orbit made very good sense for the longer term."

"They were seeking power, they weren't just seeking a particular outcome," Webb says of the presidential committee critics, barely willing to offer an olive branch after two decades. "The scientists really felt that a lot of decisions by the military during World War II were not wise and that the president must find some way to rely on scientists, who knew what they knew better than other parts of our society."

"Some people thought LOR was the craziest idea they'd ever heard," Willis Shapley remembers. "Nobody had come close to doing anything like that before. To bet all the chips on it, wasn't that the wrong idea?"

The struggle came to a peak, at least in the media's eyes, during a presidential tour of Marshall Space Flight Center in Huntsville, Alabama, in September 1962. As Wernher von Braun briefed the entourage about LOR, by then strongly favored by NASA, Kennedy interrupted saying, "I understand Dr. Wiesner doesn't agree with this." Wiesner began reviewing his objections to LOR when Webb jumped in to defend it. Kennedy stopped the confrontation by saying that the subject was still under review. The press played up the fracas angle, suggesting there might be weaknesses in Apollo's technical framework.

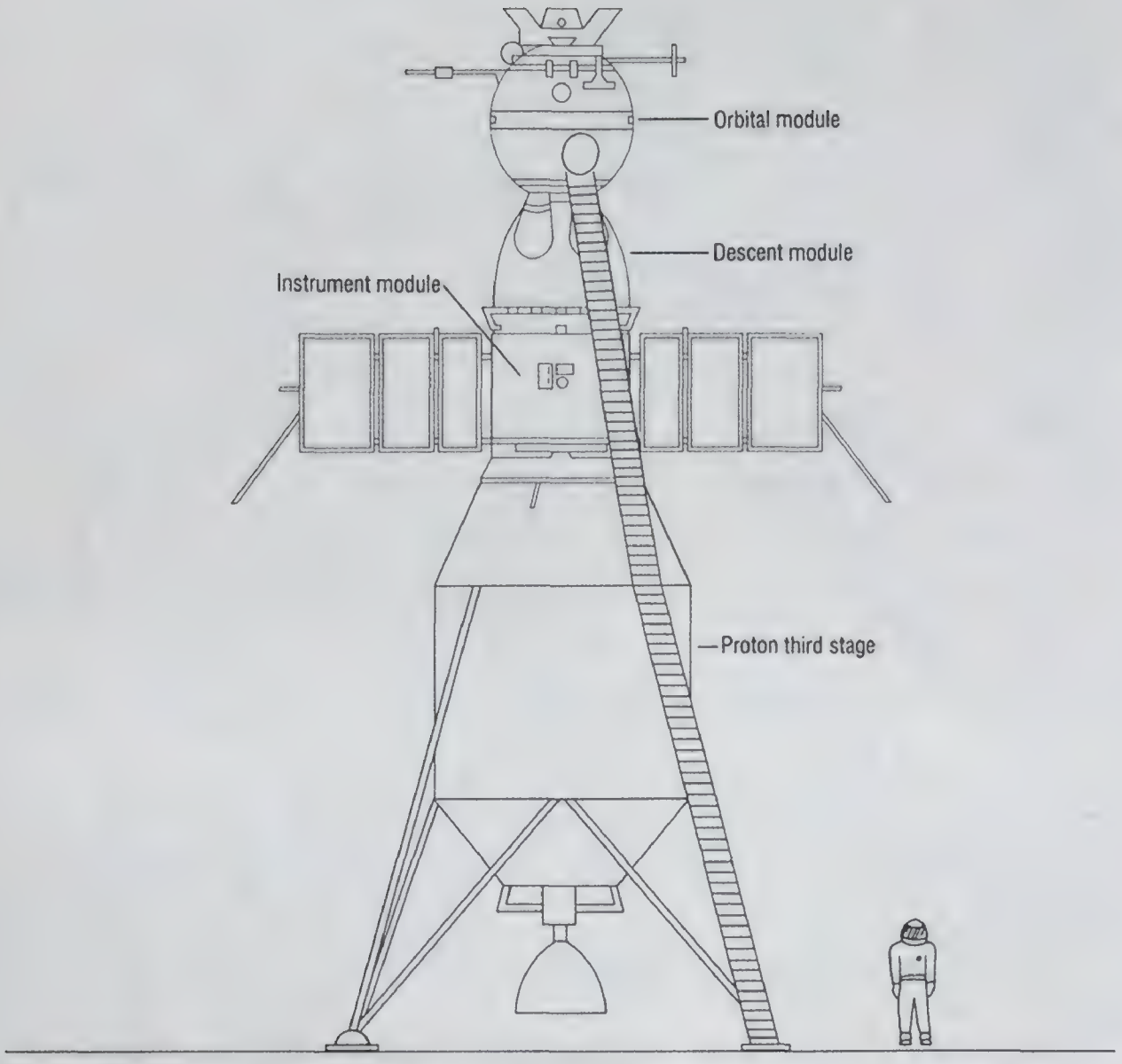
Wiesner maintains today that "von Braun and I were just talking. I remember I asked him some question about the rocket, and he was answering, when Jim Webb—who thought we were arguing—came up and *started* an argument." Wiesner still believes that LOR was more of a "political accommodation" to internal rivalries among NASA's own research centers than a solution based purely on technical merit. With a laugh, he recalls Kennedy's quip to Solly Zuckerman, the British government's scientific advisor, who had wondered which faction would win: "Webb's got all the money, and Wiesner's only got me."

The next four years, until the beginning of 1967, were bread-and-butter times for Apollo. The herculean engineering task of getting myriad contractors to produce diverse hardware and funneling the pieces to Cape Canaveral (called Cape Kennedy from 1963 to 1973) according to a lockstep schedule proceeded at a pace that has never been

> "Tell that young guy the facts of life," Johnson said to another participant.

matched. One major management decision of this period was to subject the Saturn boosters to "all-up" flight testing. This risky procedure meant that instead of testing component by component, gradually building confidence in an entire system, the full apparatus would be tested in its ready-to-fly configuration. Supposedly, this would produce a maximum amount of information from a minimum number of flights, but it is not considered orthodox engineering. It is often seized upon when a costly program is under intense schedule pressure. Indeed, NASA made the all-up move after a mid-1963 internal study calculated the chances of landing on the moon by 1970 at only one in 10.

"Working for NASA was, at times, hell," says George Skurla, who directed the Grumman Corporation's work at Cape Canaveral and then went on to become the company's president. "At the Cape, all the hardware was feeding in from all over the United States to make up that 363-foot stack of launch vehicle and payload. NASA had to be awfully demanding and, you might say, arrogant. One of the outstanding accomplishments was putting together this government-industry team and marching the whole parade to a common drumbeat. But it left a lot of human wreckage in its wake in terms of broken families, divorces, and busted profes-



The Other Side of the Race

Could the Soviets have intended to combine a Soyuz vehicle and a Proton booster to create a moon craft?

In the summer of 1969 reports began circulating in the West that a powerful new Soviet booster had exploded at the Tyuratam launch complex. The Soviets had been preparing the gigantic rocket for either a static test or an actual launch when its propellants ignited. The explosion not only destroyed the launch vehicle and its complex, it also put an end to Soviet hopes of winning the race to the moon.

The Soviets never publicly acknowledged the Tyuratam disaster, even though the damage was extensive enough to be photographed by U.S. reconnaissance satellites. And while Westerners believe that there was in fact a space race between the United States and the Soviet Union, with the well-defined goal of placing a man on the moon and returning him safely to Earth, the Soviets have never admitted to participating in such a contest. It has taken careful analysis of the Soviet space program—often with the benefit of hindsight—for Western observers to conclude that until the Tyuratam explosion the Soviet Union certainly did have a program to rival Project Apollo.

Throughout the 1960s Soviet scientists and cosmonauts made comments indicating that they were in competition with Apollo. In 1967-68, however, they became more guarded. Although the Soviets were able to fly unmanned craft to lunar distances and test their lunar vehicles in Earth orbit with men aboard during 1968-69, there was speculation in the West that they were facing technical problems. The Soviets would not comment, however. To understand their reticence it is essential to recall their attitude at that time: in space—as in all high technology—during the 1950s through the 1970s the Soviets *never* came in second.

The first element of their manned lunar effort was the Zond series of spacecraft, an offshoot of the Soyuz vehicle that made its first unmanned flight in 1966. Zond 5 flew around the moon in September 1968. Launched by a four-stage Proton booster, Zond 5 looped behind the moon, then returned to Earth to splash down in the Indian Ocean. Zond 5's mission profile wouldn't have been acceptable for a manned flight, however: its reentry G-loads were much too high. Two months later Zond 6 rectified the problem with a "double skip" reentry that resulted in lower G-loads. According to a statement released after the mission, Zond 6 was intended "to perfect the automatic functioning of a manned spacecraft that will be sent to the moon." This is the most explicit admission the Soviets made about the existence of a manned lunar effort.

NASA officials were concerned that after the Zond flights and the successful Soyuz 3 mission in October 1968, the Soviets would attempt to fly a manned Zond around the moon before Apollo 8 could accomplish the same mission. The Zond launch window came at the end of the first week in December 1968 but no launch took place. Most likely excessive vibration made the first stage of the Proton booster unsafe for manned flight.

Analysis of the Soyuz spacecraft provided more evidence that the Soviets were aiming for the moon. Unveiled to the world on the Soyuz 3 mission, this new generation of spacecraft had three modules: an instrument module, a descent module that carried the crew at launch and recovery, and a spherical orbital module, mounted topmost, which was described as workspace for experiments. (The Zond lacked only this spherical module.) Observers of the Soviet space program were struck by one design anomaly: the orbital module was oriented differently from the descent module, with its "up and down" in different directions. If the spacecraft were sitting on its base with the orbital module on top, crew members in the descent module would be on their backs looking up the craft toward the orbital module, much as Apollo crews were in the command module. When they were in the orbital module on the top, the cosmonauts' would be standing with their feet pointing down along the length of the vehicle. It was as if the orbital module were designed for work in a gravitational field, much like the ascent stage of the Apollo lunar module.

In retrospect, it is obvious that the Soyuz was designed to carry men to and from the moon. During the landing, cosmonauts would stand upright in the orbital module, looking down at the moon during touchdown. The orbital module hatch would face down toward the lunar surface after the landing, allowing easy exit and return.

The major missing element for a Soviet lunar mission was a giant booster equivalent to the U.S. Saturn V. In 1967 NASA administrator James Webb testified before a Congressional committee that the Soviets were developing such a booster, which was dubbed Webb's Giant in the U.S. press (the defense department used the designations SL-15 and TT-5 for the vehicle, also called

a G-type booster). Rumors and satellite photography indicated that the giant booster was being readied for flight, possibly in an attempt to beat Apollo to its lunar goal. The explosion in July 1969 effectively dashed those hopes. The Soviets did fly two more Zond flights around the moon, but two more SL-15 failures ended the Soviet manned lunar program.

It wasn't until 1984, when they started to reveal details about the Proton booster, that the Soviets provided the first clues about the profile for a lunar mission with Soyuz. The second and third stages of the Proton vehicle apparently would have been coupled with the SL-15 booster, just as the upper stage of the U.S. Saturn 1-B would fly on the giant Saturn V.

The Proton's second stage was just the right size to take the Soyuz and third stage out of Earth orbit and into a translunar trajectory, while the Proton third stage had just the right propellant load to place a fully fueled Soyuz into lunar orbit, land it on the moon, and re-launch the landing craft either into a direct return trajectory to Earth or into lunar orbit, where the Soyuz could use its own propellant for a return to Earth. With this mission profile, the Soviets could have flown a mission to the moon with no need for rendezvous and docking and therefore no separate lunar module. It would have been a long descent down a ladder from the Soyuz to the lunar surface, but some early Apollo concepts called for a similar long climb down to the moon.

The SL-15 booster was scrapped after the third launch failure, but other elements of the program have seen regular use since then. The Proton booster is regularly used for unmanned flights, while modifications of Soyuz are still in use for manned flights. In the last 20 years all the elements of the manned lunar complex have been man-rated: only a giant booster has been missing. The introduction of Energia in 1987 could allow the Soviets to reconstruct their 1960s lunar mission profile at short notice (if they want to) and fly men to the moon in the early 1990s. Realistically, though, such a mission would require the introduction of completely new spacecraft.

The Soviets have yet to put men on the moon, but when they do, it is unlikely they will abandon it as the United States did after Apollo 17. We are no longer in an era where the Soviet Union would pull off a major spaceflight stunt simply to beat the United States. Clues to the Soviet philosophy are provided by recent statements indicating that they hope to fly the first men to Mars in about 2007, and they hope to begin a permanently manned base on that planet by 2015.

—Phillip S. Clark

sional careers. The guys were so caught up and driven that they let their families drift, or if they gave NASA a hard time about something, they'd be summarily thrown off."

Doubts about NASA priorities and methods were perhaps freer to surface following Kennedy's assassination, especially among scientists who feared that the gargantuan costs of manned spaceflight would starve "real" space science. Unmanned probes such as Ranger and Surveyor were being subordinated to the lunar landing mission, which was consuming more than two-thirds of the annual space budget. NASA established science planning teams to propose lunar research, but to outside scientists this looked like little more than window dressing. It was to be a perpetual dilemma.

There were other budgetary concerns: the escalating American involvement in Vietnam and costly social programs were putting a strain on the federal coffers. With domestic tensions rising, many Americans began to see the goal of putting a man on the moon as one the country could not afford.

"From the time Johnson came in, you could feel the constraints," recalls Robert Seamans, NASA's associate administrator from 1960 to 1965 and deputy administrator until 1968. "I remember going to a meeting of cabinet and agency officials when Johnson was trying to cut the federal budget by five percent. He gave us a big lecture in straightforward, barnyard language about cutbacks. When we left the meeting, he wanted everybody to shake his hand and promise they would cut their expenditures by five percent. When it was my turn to go through, I decided I would say, 'We'll obviously do our best to comply, Mr. President, but I'm sure you wouldn't want us to jeopardize the safety of the astronauts.' He didn't like that. The president then told one of the other participants to 'tell that young guy the facts of life.' "

Through 1965, Apollo managers and engineers were especially plagued with the dual challenges of shaving cost and weight from the program—two factors that have resisted firm estimates since the earliest days of aviation. Construction of the command module by North American Rockwell (now Rockwell International) was haunted by the torturous arguments about LOR, resulting in two different modules in production and continual design changes. The lunar landing module, built by Grumman, was in danger of growing too heavy to lift. With engineering design nearly complete, Grumman was forced to "scrape" (the actual name of one of its weight reduction projects) some 2,400 pounds from the 33,000-pound lander. One result was the distinctive foil wrapping that replaced rigid heat shields, saving about 110 pounds. But the desperate measures also made the lander fragile and difficult to fabricate, requiring even more human attention. Both North American and Grumman saw their cushy cost-plus contracts changed to incentive agreements, whereby the companies faced stiff financial penalties if technical criteria were not met.

"Working at NASA left a lot of human wreckage in its wake."

"I don't think NASA paid for more than about 70 percent of the true human effort that went into Apollo," Skurla says. "A lot of people worked day and night. We all were swept up in it. I call the story of my life then 'the agony and the ecstasy.' "

On the evening of January 27, 1967, three Apollo astronauts, including Gus Grissom, one of the original Mercury seven, died grisly deaths when some electrical equipment in the all-oxygen atmosphere of their test command module accidentally ignited. An investigation blamed the Apollo 1 tragedy on "many deficiencies in design and engineering, manufacture, and quality control." Heads rolled at both NASA and North American, direct costs to the Apollo program reached $410 million, and the first manned flight test was delayed for 18 months. At the time of the disaster, schedules had included a possible lunar landing before the end of 1968.

Instead, 1967 and most of 1968 were devoted to unmanned flights of the Saturn rocket and payload. These were successful enough to risk a manned Earth-orbit flight, designated Apollo 7,

by October 1968. Apollo missions 8, 9, and 10 continued the dress rehearsal as a new president took office, the Vietnam War and domestic racial turmoil sapped the nation's enthusiasm for space, and the federal budget suffered its largest deficit since World War II. The sanctity of John Kennedy's challenge was fading fast.

The objectives of the July 1969 Apollo 11 mission were listed by NASA officials in an implementation plan as follows: "1. Perform a manned lunar landing and return. 2. Perform selenological inspection and sampling." In other words, get there, pick up some rocks, come home.

And that's what they did.

Looking back on those heady days 20 years later, key Apollo players share wistful memories interspersed with regrets that the times have changed and that the political and economic circumstances behind them seem unlikely to converge again.

"I remember going up to Montrose Park in Georgetown after telling the House authorization committee that we could do Apollo," Robert Seamans says. "It was a night with a full moon. I looked up and wondered if I was nuts. I think everybody had a little of that feeling."

James Webb recalls a party at his Washington home during the early years, when Vannevar Bush, a science advisor to F.D.R. and one of the nation's most prominent scientists, "grabbed me by the lapels and shook me, saying, 'What are you doing, you're going to kill these men!' "

Webb admits that some of his Apollo methods would be inappropriate today but is not eager to muse about what might be appropriate. Seamans laments that the NASA of the 1980s is "mostly a contract administration agency," with little funding flexibility to maintain a cadre of people developing bold new ideas. As Robert Gilruth cautions, it is hard for any cutting-edge organization to last so long, "especially without anything new on the horizon.

"It was a good thing for us that we had a young president," Gilruth concludes. "And it was fortunate that the task he assigned us was something that could be done. It wouldn't be easy to do again."

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APOLLO LOG

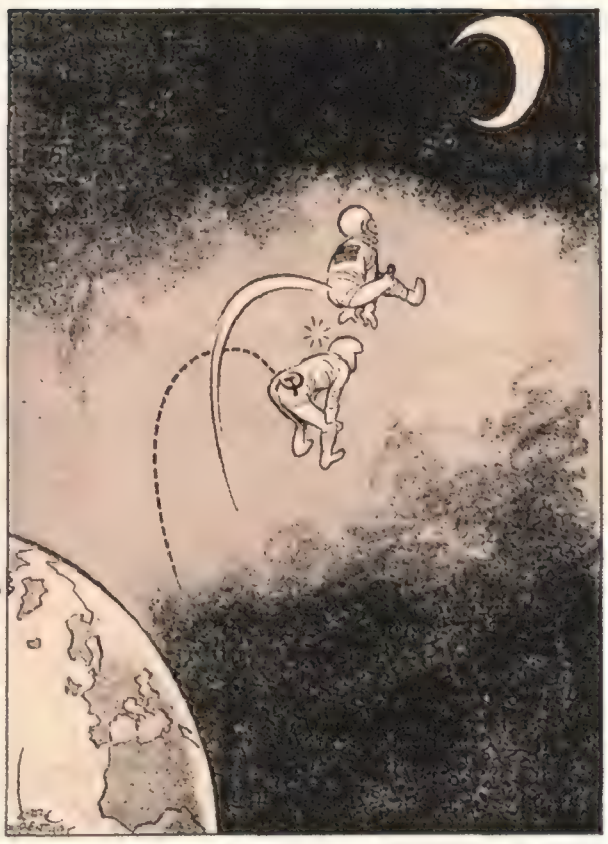
Wayne Stayskal, July 21, 1969

The cost of the Apollo program was estimated at between $25 and $40 billion for the 1960-70 decade. According to the Census Bureau's 1971 *Statistical Abstract of the United States,* for an American population of about 200 million people, the annual cost of the Apollo program was less than $20 per person. During that same decade, the average American spent about $80 a year on cigarettes, $50 on beer, and over $50 on liquor.

At the height of the Apollo program, some 430,000 people were employed by NASA and its contractors. In addition to astronauts, there were many less visible occupations, including animal keeper, dietician, clerical worker, draftsman, drill press operator, food preparation technician, graphics technician, pressure suit tailor, custodian, movie camera operator, public affairs officer, recovery ship crew, wind tunnel technician, survival instructor, and biologist.

In July 1967, as the race to the moon shifted into high gear, the cost to NASA in overtime alone was a record-breaking $7.3 million.

Project Apollo was publicly announced at a news conference in July 1960. The original program called for a manned circumlunar mission—not a lunar landing.



Karl Hubenthal cartoon, *Los Angeles Herald-Examiner*, 1965

Leapfrog

G. Valka, Pravda, December 31, 1957

Originally in *Telegram* (Toronto). From *Best Cartoons of The World* by the World Press Company. ©1969 by the World Press Company. Reprinted by permission of Dell

"I just wish they'd make up their lunar-pickin' minds!"

Tang, the General Mills instant orange drink mix, has long been identified with the space program. The drink mix, named for its tangy taste, went into national distribution in 1959; NASA became interested in the mix because it could be easily stored and contained vitamins A and C. Tang first flew aboard Gemini 4 and has been offered to astronauts on every flight since.

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A SMOOTH SPOT IN TRANQUILITY

They were only one small part of the Apollo project, but the responsibilities they shouldered were enormous. This group of geologists had to determine where man could first set foot on another world.

JET PROPULSION LABORATORY

by Don Wilhelms

America was determined to send men to the moon by 1969 on a stack of metal and flame called Saturn V. Eventually, the labor, skill, and dedication of some 430,000 people would culminate in lunar orbits by 24 astronauts and moonwalks by 12. The entire project, however, would have come to naught if the lunar modules had slid off a cliff, been swallowed up by deep dust, or set down in a field of boulders. To prevent such disasters, teams of scientists and engineers and a flotilla of spacecraft spent five years searching for smooth and firm landing sites.

The groundwork had been laid more than 300 years earlier, when Galileo Galilei peered through his telescope and drew a moon that appeared to have "ridges . . . which surround plains . . . . There are a very great number of smaller ones, almost all of them circular." In 1651 Giovanni Battista Riccioli began naming Galileo's circular craters and smooth, dark plains, called *maria* (the plural of *mare,* meaning "sea"). In 1840 J.W. Draper made the first daguerreotype photograph of the moon, and by the turn of the century the first photographic lunar atlases had appeared.

The search for landing sites actually got under way when astronomers began speculating about the nature of moonlight, long before anyone except a few visionaries guessed that their findings would have a practical application. By the early 1960s most of them agreed that the moon had a rough, porous surface, but there were disagreements on how much weight it could support. Theories ranged from a surface of closely packed rock and dust created from bedrock by a torrent of meteorites and comets to a dangerously weak structure consisting of volcanic "rock froth" or such exotic substances as "fairy castles" of loosely packed dust or glassy volcanic fibers. Even worse trouble was imagined by astronomer Thomas Gold, who in 1955 theorized that the maria consisted of dust so thick and weak it could swallow a lander.

Surveyor 1's touchdown in the Ocean of Storms helped dispel fears that thick dust would swallow a spacecraft.

Most scientists enjoy speculation but have a redeeming appetite for facts, and facts about the lunar surface were in great demand at the advent of the Space Age. In 1959, to keep pace with the Soviets, NASA and the Jet Propulsion Laboratory devised two lunar probe programs, the Ranger crash-landers and Surveyor "soft" landers. Originally, the independent-minded JPL scientists envisioned these robot spacecraft returning a wide variety of scientific data about the moon. But after President Kennedy's 1961 challenge to land an American on the moon before 1970, Ranger and Surveyor were transformed from robot scientists into robot engineers, charged primarily with determining if the lunar surface could support a manned spacecraft.

In 1962 Eugene Shoemaker at the U.S. Geological Survey (USGS) got a head start on site selection. He devised for NASA a lunar exploration and site

selection plan dependent on acquiring a thorough understanding of lunar geology. Gerard Kuiper, director of the Lunar and Planetary Laboratory of the University of Arizona, played a similar role on the astronomical side. His *Photographic Lunar Atlas* and *Orthographic Atlas of the Moon,* both published in 1960, contained detailed telescopic photographs and graphic representations of the side of the moon visible from Earth.

NASA took Kuiper and Shoemaker's advice and ultimately settled on TV cameras to study the lunar surface—to the horror of influential space physicists, who felt that pictures required too much interpretation and preferred quantifiable data, such as measurements of solar radiation. The first six Rangers failed, but in 1964 and 1965 Rangers 7, 8, and 9 relayed some 17,000 images in the last moments of their kamikaze missions. The pictures, which revealed features as small as one foot, supported the impact-debris theory. Furthermore, the presence of a few rocks convinced most investigators that the surface could support heavy objects. Gold, however, remained unconvinced, which further agitated the fears of cautious Apollo engineers.

NASA had more to worry about than killer dust in choosing a landing site. To sort out all the scientific and engineering considerations that governed where an Apollo could land, the agency turned to the Bell System and its engineering expertise. After analyzing factors such as communications, tracking, fuel capacity, rocket performance, and launch schedule slippages, Bellcomm, Bell's elite new division, and NASA's Manned Spacecraft Center (MSC) in Houston concluded that the safest and most effi-

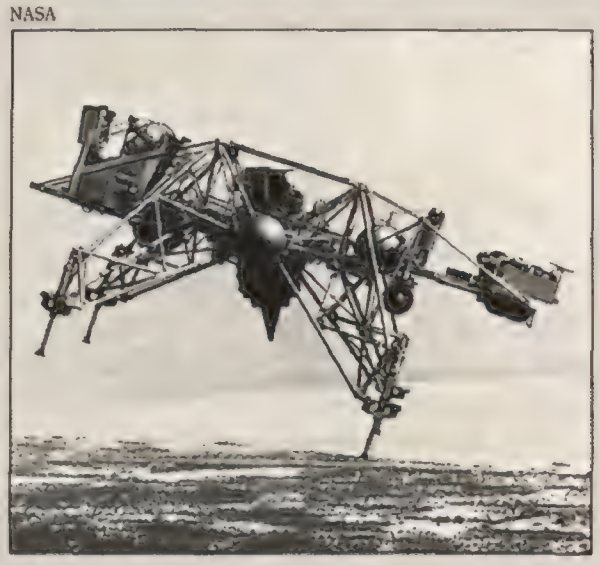
The Last 500 Feet

While geologists searched for landing sites, astronauts practiced in the Lunar Landing Training Vehicle. The LLTV looked like a jet-powered Tilt-a-Whirl, but in fact it was an ingenious application of vertical-takeoff-and-landing propulsion that simulated maneuvering in the moon's reduced gravity. Bell Aerosystems assembled five trainers (including two for research), each built around a jet engine, two large hydrogen peroxide rockets, and clusters of smaller rockets mounted on a four-legged platform of steel tubing. There were no wings or other aerodynamic surfaces, so if the engine or rockets quit, the pilot yanked the ejection seat handle and punched out—*fast.*

Dubbed the Flying Bedstead, the LLTV was not user-friendly. Astronauts geared up for it in helicopters and in tethered and ground-based simulators. When they finally worked themselves up to fly the LLTV at Ellington Air Force Base in Houston, they attracted the attention of motorists on Old Galveston Road, who would stop to watch the show.

"It's really a great deal different than any kind of aircraft I've ever flown," was Neil Armstrong's diplomatic critique after several flights. "Like flying an unstable elevator," recalls Apollo 8 commander Frank Borman. The pilot fired up the jet engine mounted on a gimbal in the center of the platform, locked it into vertical position, and shot up to about 500 feet. He then switched to the "lunar sim" mode for the descent. The engine was first throttled back to support only five-sixths of the trainer's weight in order to mimic the effect of lunar gravity and was then unlocked so the platform could move freely while thrust remained vertical. The two large rockets, linked to a throttle in the cockpit, were ignited to control the descent. A sidearm control in the cockpit, a duplicate of the one in the lunar module, fired the small rockets to control pitch, roll, and yaw. As the pilot sought the proper ratios of thrust, the LLTV took on the appearance of a flying calliope, lurching and wobbling and emitting erratic puffs of peroxide steam.

NASA



The capricious Lunar Landing Training Vehicle taught Apollo commanders how the real lander would behave in lunar gravity.

"It was the hairiest part of the program," says Apollo 12 commander Pete Conrad, who made 14 LLTV flights. "It didn't take long before we lost one, then two and three. But with the state of simulation in those days, it was the only way to do the last 500 feet."

To prepare the astronauts for emergencies, the LLTV was occasionally programmed to fail. "We didn't do that often," says Apollo 14 commander Alan Shepard, "because everyone was so damn glad when you got the thing down okay."

When all systems functioned properly, the flights were fairly routine. When they didn't, the Old Galveston Road spectators got a spectacular show. During Neil Armstrong's 21st training flight, a loss of pressure in the hydrogen peroxide tanks shut down the attitude control rockets. The trainer tilted wildly and began to spin. Armstrong ejected at 200 feet, landed in the grass by the runway, and walked away. The trainer exploded.

Several months later gusty winds blew another LLTV out of control. NASA pilot Joe Algranti ejected one second before it crashed. And about two years later test pilot Stu Present ejected after an electrical system failure again shut down the attitude control rockets.

With pilots popping from stricken trainers like champagne corks, NASA had second thoughts on the need for LLTV training. "We felt maybe it wasn't worth the risk," says Christopher Kraft, then chief of flight operations at Houston's Manned Spaceflight Center. Originally all Apollo astronauts were to fly the LLTV, but soon the list was narrowed to mission commanders and their backups. "After each crash," says Conrad, "Dr. Gilruth [the Manned Spacecraft Center director] would ask each commander if he *really* felt it necessary to fly the LLTV."

In November 1972, one month before the last lunar mission, Apollo 17 commander Eugene Cernan made the last LLTV flight, and NASA promptly gave the two surviving trainers to museums. More than 500 LLTV flights had caused widespread fingernail-biting, but it had all paid off. "Every astronaut who made a lunar landing told us that the LLTV was by far the most important training vehicle they had ever flown," says Kraft.

"Landing on the moon was such a bizarre thing anyway," says Shepard, "anything we could do to prepare for it was a help."

—*Patricia Trenner*

NASA

Lunar Orbiter 4's wide-ranging view of the moon was pieced together on the floor of a NASA auditorium.

cient route for a manned mission was from Earth's equator to the moon's. Site selectors focused their attention on a 185- by 1,675-mile swath that ran five degrees north and south of the lunar equator and 45 degrees east and west of the central meridian. This was where five Lunar Orbiters, built by Boeing for NASA's Langley Research Center, would search for sites for both Surveyor and Apollo, and where Surveyors would scrutinize the surface.

An engineer could have mapped the visible obstacles, such as mountains and large craters. The maria appeared relatively flat and smooth, and the craters and *terrae,* or highlands, were rough. But it would take geologic mapping to locate less obvious hazards. Geologists had learned through telescopic observations that lunar craters are surrounded by rough ejecta blankets, except where dark mare areas clearly extend to the crater rim. Therefore, large craters with no nearby mare surfaces were excluded as potential sites even when no ejecta blanket was visible. Bright rays, projections of lighter material that surround the freshest craters, were avoided because of their many pits and grooves. Bright patches of maria were ruled out even when individual rays could not be resolved, because slopes of small craters and small "islands" of terrae are also bright and could contribute to the overall brightness of a patch of mare. The whole exercise boiled down to the conclusion that dark plains were smoother than light plains and therefore more attractive landing sites. Shoemaker's USGS astrogeologists and JPL analysts first took moon maps and drew ellipses equivalent to 30 and 60 miles in diameter over terrain lacking observably rough objects. Later, the USGS converted many of these sites into a series of up to 13 rectangles to be scrutinized by a Lunar Orbiter.

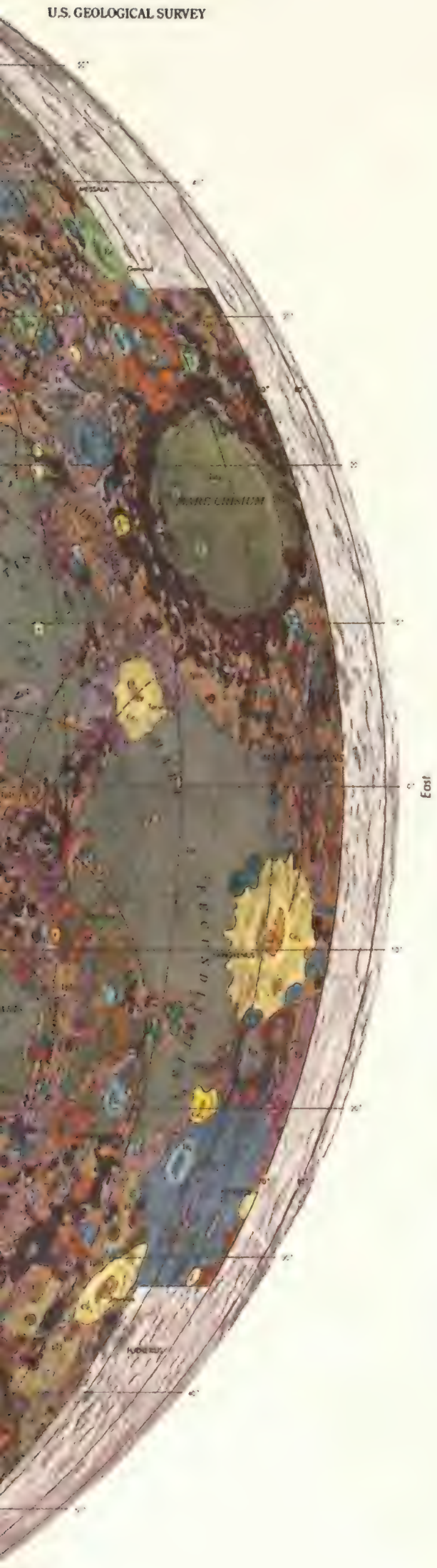
In 1966 the Soviet Luna 9 and the first Surveyor both made soft landings that barely dented the moon, confirming Ranger-based hypotheses that the surface held no fearsome properties. There was no deep dust or obvious porous structures—just rocks and craters. The following year Surveyor 3 scooped the surface to test its properties directly, and Surveyors 5 and 6 carried devices to determine its chemical composition, which resembled that of terrestrial basalt, a dense, dark volcanic rock.

Determining where the Lunar Orbiters should concentrate their attention fell primarily to USGS teams, with early missions led by Jack McCauley and Lawrence Rowan and later ones by Harold Masursky (see "Putting Mars on the Map," October/November 1987) and myself. We were joined at the site selection meetings by Bellcomm geologists Noel Hinners and Farouk El-Baz and by geologists and astronomers from MSC, NASA headquarters, and Kuiper's Lunar and Planetary Laboratory. Of course we could not dictate the sites. First they were filtered through the Lunar Orbiter Project Office. MSC tested our recommendations against Apollo's requirements. The final say belonged to the Surveyor/Orbiter Utilization Committee, established to ensure that the Surveyors were well served by the Lunar Orbiters and that Apollo was well served by both.

In 1966 and 1967 the first three Orbiters photographed 34 potential Apollo sites in 11 areas from as low as 30 miles. During the intense weeks following each mission, teams of up to 60 geologists, terrain analysts, and workers at the USGS, NASA, Bellcomm, and military mapping agencies pounced on the resulting images. The USGS continued the mapping of geologic units and ter-

A decade of telescopic and Orbiter photos contributed to a U.S. Geological Survey lunar map compiled by the author and Jack McCauley.

U.S. GEOLOGICAL SURVEY



rain types that it had begun with telescopic photos, while the other agencies sought ellipses where an Apollo could land with maximum safety.

Ellipses were rated with an "N-number," which expressed the ratio of landable to unlandable terrain. An ellipse earned a low N-number if it contained too many large boulders, sharp craters, or slopes greater than seven degrees. High obstacles in a future lander's approach or departure path were unwelcome, and faults or cones that interested geologists were usually too rugged to be safe. (MSC analysts, unfamiliar with how the appearance of a lunar feature like a crater changes with the angle of the sun, initially assigned the best N-numbers to sites that had been photographed with the sun at a high angle. This led Hal Masursky to suggest that the Apollos always land during a full moon.)

After the Orbiter 3 mission in February 1967 NASA was satisfied that it had found enough smooth spots, and dispatched Orbiters 4 and 5 to survey the entire moon, searching for sites where later Apollos could land. But MSC was not *quite* satisfied; Orbiter 5 also rephotographed five potential sites for the first Apollos, including one named Orbiter 2P-6, the highest ranking of the Orbiter 2 targets. These and other prime sites were also photographed obliquely toward the west to provide a landing astronaut's view.

By January 1968 five prime Apollo sites had emerged, numbered east to west. Sites 1 and 2—the latter Orbiter 2P-6—were at the southern edge of Mare Tranquillitatis. Site 3 was in the center of Sinus Medii, and sites 4 and 5 were in Oceanus Procellarum.

By the end of the year NASA had settled primarily on sites 1 and 2. The agency preferred an eastern site for the first mission—if a launch was delayed, there were western sites like Sinus Medii as backups. Site 1 was very smooth, but was geologically too unusual for the scientists. Site 2 also seemed smooth, and one of its ellipses had earned the highest N-number given—0.907. It had more large craters than the western sites but they had low, smooth rims and walls. More importantly, site 2 had fewer boulders.

In December 1968 Apollo 8's Frank Borman, Jim Lovell, and William Anders looked down at sites 1 and 2 from an altitude of 70 miles and saw nothing threatening. In the following months NASA homed in on site 2, and in May 1969 Tom Stafford and Eugene Cernan swooped down to within 10 miles of it in Apollo 10's lunar module and said it looked good to them, too.

Site 2 also looked good to the geologists who had zeroed in on it first as a dark spot seen through a telescope, then as a Surveyor ellipse, and finally as an Orbiter rectangle. The location satisfied all of NASA's complicated conditions for safety, fuel consumption, communications, and backup sites. In June 1969 NASA engineers and administrators put their final blessing on site 2, with sites 3 and 5 as backups.

On July 20 Neil Armstrong and Buzz Aldrin made the final site selection as they steered the *Eagle* toward the designated site. They landed long to avoid a 40-foot-wide crater and some large boulders. The *Eagle* finally touched down at 0.7 degrees north, 23.4 degrees east—a point known today as Tranquility Base.

NASA

In 1969 Apollo 12's Alan Bean paid a visit to Surveyor 3, the first to scoop up a sample of the lunar surface.

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The rocket that hurled men to the moon was driven by genius from Germany and engines made in the U.S.A.

by T.A. Heppenheimer

The Saturn V was such a giant that it inspired the press to find ever more startling expressions of its awesome dimensions. The three-stage rocket with its payload was "as tall as a 36-story building," "two-thirds as tall as the Washington Monument," and "taller than the Statue of Liberty," as well as 13 times heavier. A promotional brochure from a major contractor, North American Rockwell, announced that the fully loaded Saturn V weighed 800 tons more than "a good-sized Navy destroyer." Some of its fuel lines were big enough for a man to crawl through.

The gargantuan first-stage engines, 19-foot-tall F-1s built by Rocketdyne, were singled out for special attention. They would accelerate the 3,000-ton rocket to "more than 40 times the speed of a jet airliner." The combined thrust of the five engines was 7.5 million pounds.

These are all impressive figures, but the most important Saturn statistic is a modest number: 32. There were 32 Saturn launches altogether, including the smaller Saturn I and Sat-

NASA

Wernher von Braun (1912–1977) watched over every stage of the Saturn V's development, sometimes from a blockhouse near the launch pad.

NASM

urn IB rockets. All 32 were successful. The reliability of the launch vehicle was the result of the most exhaustive ground testing program in aerospace history, as well as a philosophy that emphasized refining technology instead of inventing it. The people who built Saturn had lost a number of rockets in earlier development programs and had blown up more than a few engines. On Saturn they were making already-understood systems better—and bigger.

While Wernher von Braun was accumulating data from V-2 launches in the New Mexico desert, a group of engineers who would later form Rocketdyne were making California canyons rumble with engine tests. They started by building copies of a V-2 engine. They invented a more robust injection system, a more efficient cooling system, faster turbopumps. By the time they fired the complete XLR-43, rated at 75,000 pounds of thrust, about the only thing it had in common with the 56,000-pound-thrust V-2 was its fuel: alcohol mixed with liquid oxygen for combustion.

In November 1949 von Braun dropped over to the Santa Susana canyons to observe the first firing of the engine thrust chamber. A technician called out "Mainstage" as he started the test—and the chamber exploded. Cryogenics headache number 27: Mild steel, made brittle by exposure to the extreme cold of liquid oxygen, cracks under the high pressure in a rocket motor. The faulty components were replaced with stainless steel, and several months later the thrust chamber proved itself. Impressed by its power, von Braun, after joining the Army Ballistic Missile Agency in Huntsville, Alabama, chose the engine for the Redstone rocket and the Jupiter C, which, on January 31, 1958, launched the first U.S. satellite.

At the time, von Braun was in a position to take advantage of his triumph with the Jupiter C. He was the chairman of a working group on launch vehicles appointed by the National Advisory Committee for Aeronautics to assist in the planning and coordination of space projects. Rocketdyne's president, Sam Hoffman, worked on the committee with him. "You couldn't help but be impressed with the work he had done," says the 87-year-old Hoffman today. "I think he would have gone even farther if it hadn't been that he was on the wrong side in the War. He was a leader. He had charisma."

Hoffman recalls a visit from von Braun at a time when everybody in the rocket business was working on missiles for the military. "He came down to my home. He had a big blueprint of a space station, which he spread out on my living room floor. That was what interested him; these other things were just steps along the way."

With Hoffman as the engine expert, von Braun's group recommended rockets for space stations, a manned lunar landing, a permanent moon base, and manned interplanetary trips. By the time the full committee made its final report in October 1958, NACA had become NASA. Several committees later, NASA would choose the moon as its goal. In the meantime, Rocketdyne and von Braun continued to use military funding to develop hardware for space exploration.

David E. Aldrich, the F-1 program manager at Rocketdyne, had been hired away from Curtiss-Wright in New Jersey, where, "with four men who had worked for Dr. Goddard," he helped develop the engine for the X-2 research aircraft. "I got a lot of valuable ideas from them on what it took to make a successful rocket engine," Aldrich says. "The F-1 was so

The F-1 engine for the Saturn V dwarfed its predecessor, the H-1, which powered the first stages of earlier Saturns.

ROCKETDYNE

In seconds after ignition, an F-1 harnessed to a "battleship" test stand unleashes 1.5 million pounds of thrust.

much larger. It was kind of special to itself."

According to Aldrich, the first hurdle in engine development is the injector—"That's the heart of the engine," he says. The injector is a disc of concentric channels for fuel and liquid oxygen, pierced with holes through which the propellants are sprayed into the combustion chamber. It resembles a shower head, but is a considerably trickier piece of equipment since it must control the relative amounts of propellants entering the chamber as well as the angle at which they impinge in order to achieve efficient and uneventful combustion.

The F-1 injector, which was the size of a manhole cover, would channel three tons of propellant per second into the engine's cavernous combustion chamber. Combustion was so violent that it triggered shock waves, producing more heat than the engine's cooling systems could handle. During a static test on June 28, 1962, an F-1 engine was destroyed when the fire in the chamber burned through the injector. The Marshall Space Flight Center, which had opened under von Braun's leadership in 1960, immediately set up an ad hoc committee to study combustion instability. Paul Castenholz represented Rocketdyne on the committee and spent 18 months working full time on the problem.

"We went through 30 different injector designs, during a year and a half," recalls Castenholz. "None of them worked." The new designs reduced the severity of the problem, but as work progressed, the engineers ran into a situation familiar to any car owner whose car has stalled on the highway, then run perfectly in the shop. Engineers would run a series of three or four successful tests, believe the problem solved, and run up against it on the fifth. "We had to develop a method of making it occur," says Castenholz, "so we developed a bomb."

The bomb was a small explosive charge, or cluster of charges, set within the combustion chamber. With the rocket firing, the test engineer would push a button and set off the bomb. This triggered a momentary surge, from which the engine would have to recover.

They tried dividing the combustion chamber into sections by installing baffles—inches-tall ridges—on the injector face. If a detonation wave began to form and move within the combustion chamber, it would quickly encounter a baffle and die out. Each combustion region thus was isolated.

The baffles and a combination of very delicate adjustments, such as enlarging the diameters of the 3,700 holes for squirting fuel and the 2,600 holes for squirting oxidizer, solved the problem—but not before managers at NASA headquarters began questioning whether F-1 combustion instability was going to lose the country the space race. According to historian Roger Bilstein in his book *Stages to Saturn,* von Braun sent a memo to reassure the group in Washington "but promised no quick or easy solutions."

"Wernher always seemed to be older than he was," says Castenholz. "You looked up to him as having a lot of experience, a very strong vision." Holding on to his vision required von Braun to adjust it several times since he first spread the blueprints of a space station on Sam Hoffman's living room floor. One of the most difficult adjustments came in 1962, by which time NASA had decided to go to the moon but was mired in the debate over how to get there.

Of three possible mission profiles, the one most easily dispensed with was direct ascent from Earth to the lunar surface. It would have required an enormous rocket with 12 million pounds of thrust in its first stage. Not surprisingly, von Braun already had the rocket on the drawing board—he named it Nova—but even he acknowledged that it couldn't do the job by the deadline President Kennedy had imposed in 1961.

Probably the most convincing argument against direct ascent was offered by a man who had originally supported it, Robert Gilruth, head of the Manned Flight Center in Houston. Gilruth argued that a lunar landing would be much more safely accomplished by a spacecraft designed for that task alone than by one designed to heave itself off one planet and fly to another. He favored the lunar orbital rendezvous profile, devised by John C. Houbolt at the Langley Research Center in Virginia. Houbolt had taken the unorthodox route of writing directly to NASA deputy administrator Robert C. Seamans, bypassing everyone at Langley, to convince mission planners of the soundness of the concept.

Earth orbital rendezvous was the mode favored by von Braun and the Marshall Space Flight Center. It required build-

Incredible hulk: At more than twice the height of a Redstone rocket, a Saturn V first stage weighed 148 tons before fueling.


NASA

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NASA

ing only one spacecraft to travel from Earth orbit to the moon and back, instead of the two spacecraft required for lunar orbital rendezvous. However, the one craft would have to be assembled in Earth orbit and would depend on two almost simultaneous launches. Obviously, this profile had the endearing bonus of developing basic capabilities for space station construction. Nevertheless, von Braun let it go and announced his support for lunar orbital rendezvous.

He also yielded on the earlier issue of whether to use liquid hydrogen, an experimental fuel, for the Saturn's two upper stages. He had consistently argued against the risks of untried technology, but NASA's Abe Silverstein convinced him that the Centaur program, the first to use liquid hydrogen, would be far enough along to have yielded data on the storage and handling of a substance that boils at −420 degrees Fahrenheit. Still, despite lessons learned from earlier struggles in the Centaur program, liquid hydrogen gave the Saturn engineers plenty of opportunities for inventive problem-solving.

The Saturn V had three stages. The first was built by Boeing at NASA's Michoud Assembly Facility near New Orleans. Fueled by kerosene and liquid oxygen, it most closely reflected von Braun's motto to stick with what you know. The chief challenge in building it was its size. New welding techniques had to be invented; huge facilities with reinforced floors to withstand the weight of the heavy tooling were required.

The Douglas Aircraft Corporation built the third stage at Huntington Beach, California. Drawing on experience they had gained from the Thor program, Douglas engineers removed weight and added stiffness to the walls of the cryogenic fuel tanks by "waffling" them—scooping out metal to leave pockets and ribs. Insulating the tanks was a bigger problem. Douglas used polyurethane foam, cut in tiles to match each of the 4,300 waffle pockets. The tiles went on the inside of the tanks to protect the aluminum walls from the stresses of temperature change and to gain an advantage in the fill-and-drain operations of fueling. The fuel cooled the aluminum, but the aluminum also warmed the fuel and caused it to "boil off." Internal insulation reduced the boil-off by 75 percent.

Because the middle stage of the Saturn V, the S-II stage, was the last to be built, the contractor, North American, not only faced the same challenges with cryogenic fuels, but also had to continually reduce weight on the stage as the spacecraft weights increased. "We spent long nights at it," recalls Bill Ezell, a Rocketdyne man who worked on that effort. "I'd usually get to work at about seven in the morning and stay until seven at night. I'd do that six days a week, and sometimes seven. Almost everybody did . . . ."

Reducing weight was so critical that the S-II designers decided against internal insulation. Because aluminum gains strength at lower temperatures, North American could use thinner tank walls by exposing them to the strengthening cold of the fuel inside. Rocket builders had come a long way in 15 years—from blowing up engines made of the wrong steel to making a subtle metallurgical property work in their favor.

NATIONAL SPACE TECHNOLOGY LABORATORIES

Too heavy for land or air transport, the first stage floated by barge from its Mississippi Test Facility to Cape Kennedy.

This second stage emerged as the merest eggshell of a rocket. The tank structure weighed just over three percent of the total fueled weight. But the combined struggle to shave pounds and keep the cryogenic fuels in a condition to serve five J-2 engines in flight contributed to trauma at the Space and Information Systems Division at North American, which was also struggling with the Apollo command and service modules. Two S-II model stages ruptured during tests. Schedules were delayed. "The initial management team was replaced a couple of years into the program," says Ezell. After that, Ezell comments, "the program ran much smoother."

Forty-five individual Saturn V flight stages were built, tested, and delivered to Cape Kennedy for assembly. The fifteen S-IIs were the only ones light enough to travel on a highway. Each was loaded on a customized truck that carried it through the coastal town of Seal Beach, southeast of Los Angeles, where North American had thrown up an assembly plant. It was then loaded aboard a barge that took it through the Panama Canal and on to test facilities in Mississippi.

The Saturn's third stage was transported from California by the "Pregnant Guppy," a cargo airplane with a swollen fuselage. It was one of the more outlandish craft ever to take to the air, but it was suited to its task. The gigantic first stage traveled by barge from Michoud to Cape Kennedy, where the three stages were stacked inside the massive Vehicle Assembly Building, one of the largest enclosed spaces in the world. The first Saturn V was launched on November 9, 1967.

"Whoever made the decision had courage," Sam Hoffman says. It was George E. Mueller, the director of NASA's Office of Manned Space Flight, who made the call to risk live upper stages on the first Saturn V launch. "If someone didn't make a decision, you'd never build a rocket engine," Hoffman says, but he admits he felt some anxiety. "I was nervous every time I saw one fly, and I still am today," he adds.

A modified Boeing Stratocruiser, dubbed the "Pregnant Guppy," engorges a third stage to carry cross-country.

A Saturn V awaits its passengers. After years of building and testing, the one task left is to fly it to the moon.

"Every time a rocket engine fires, 15 or 20 thousand parts all gotta work without a flaw," says Paul Castenholz. "Two and a half minutes is a long time in the life of a rocket engineer." On the first launch, all 15 or 20 thousand parts worked well enough. Feeling triumphant, the Saturn team launched again on April 4, 1968. Unfortunately, some parts didn't function as well on the second shot.

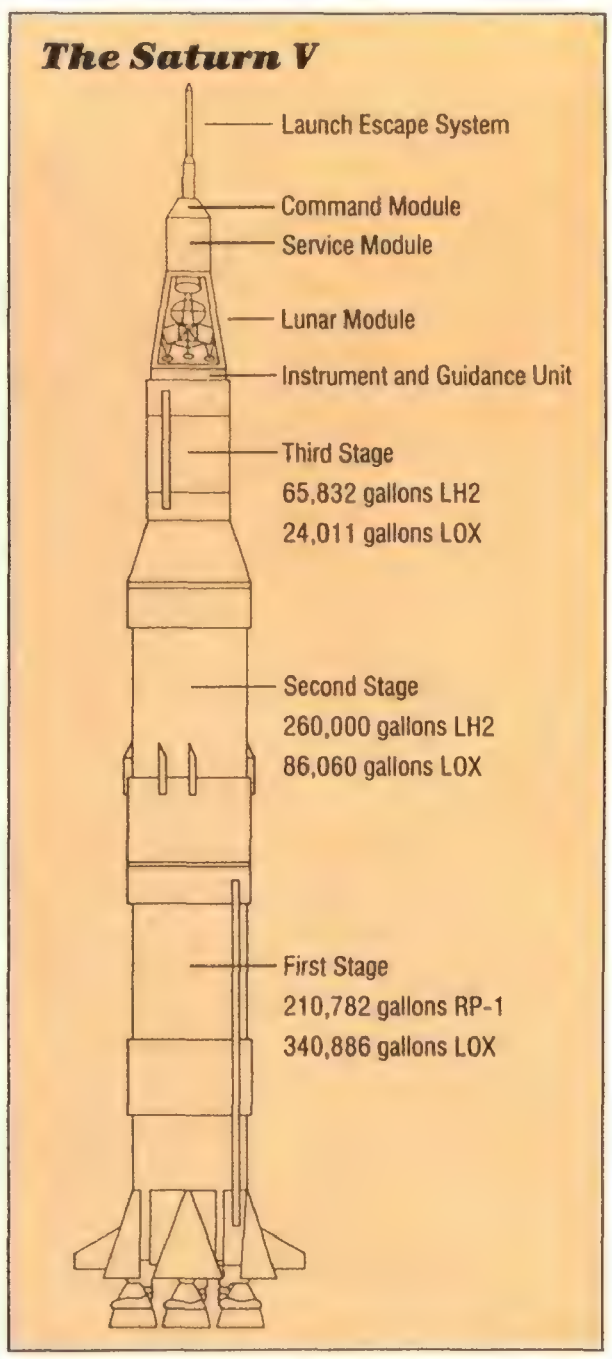
Two of the J-2 engines in the second stage shut down prematurely. The J-2 in the third stage failed to restart on command, leaving the stage stranded in orbit. Although the Apollo spacecraft made it to orbit and the launch satisfied many primary research objectives, the failure of the engine to restart meant that the rocket could not be counted on to carry astronauts—and astronauts were scheduled for the next launch.

Castenholz by then was the J-2 project manager. "At the end of the flight," he recalls, "we went into a big meeting room at Cape Kennedy." Ranged before him were the directors and managers of the entire Apollo effort, who had come to see the launch. "I said, 'I have to tell you we don't know what happened. But we will immediately go on a 24-hour schedule, and we will keep you informed.'

"It was probably my lowest point as a rocket engineer," he adds. "I was thinking, *What could be worse than this?* I remember driving down the street, coming home, thinking, *This is terrible! This is the wrong place to be!*" He organized a round-the-clock effort. Hoffman called every man he could spare from other programs. Castenholz had cots brought in.

The investigation was difficult because there was no failed hardware to examine. The second stage had burned up in the atmosphere, and the third stage was in orbit. There was only meager data from telemetry because of the limited number of data channels for transmission from a Saturn V. During three previous test flights the J-2 engines had performed well, so after each flight, data channels had been taken away from the J-2s and reassigned to other rocket systems. And information from ground tests would have limited value since a J-2 had never failed in this fashion on the ground. The engineers conducted a meticulous review of past tests anyway, hoping that something would turn up.

The break came after only a few days. Castenholz and a colleague, Marshall McClure, had been agonizing over why the engine had failed in space but not on the ground. They kept studying over and over the movies of J-2 tests on the Rocketdyne test stands. Then Castenholz saw what he had not noticed previously, or at least what he had failed to regard as significant. Ice was building up on many of the fuel and oxygen lines because the supercold liquids they carried caused water from the air to condense on them. In space there was no air that could form ice. The ice must have been helping the engine.



Many of the J-2 propellant lines were corrugated to make them flexible, like a vacuum cleaner hose. The flexibility permitted vibration, and if the vibrations became severe enough, a line would break. But at Santa Susana, ice building up within the corrugations—which were known as "bellows"—could keep the vibrations from growing in strength. That might be why a line would work on the ground but would weaken and break after a few minutes of vibrating in space.

The meager telemetered data from the Saturn V had been enough to focus Castenholz's attention on a particular area of the engine. Only one such corrugated duct was in that area, the auxiliary spark plug igniter fuel line. "It was covered with a stainless steel mesh," says Castenholz, "so it didn't jump out at you that it was a bellows. But when you watched the film, you could see the ice form."

Castenholz had previously arranged to have a specialized test facility built, in which he could test such components under vacuum. His engineers put eight of these fuel lines into the test chamber, operated them under conditions that would duplicate those of a J-2 firing in space—and watched all eight lines rupture. Once a rigid stainless steel pipe was substituted, the Saturn V was qualified to carry astronauts. The way was then clear for the Apollo 8 flight to the moon.

Just after dawn, four days before Christmas in 1968, three astronauts—Frank Borman, Jim Lovell, and William Anders—lay in their contoured couches at the tip of the rocket. Walter Cronkite led millions of viewers through the live television coverage of liftoff.

"Twelve, eleven, ten, nine," intoned Jack King of NASA's mission control. "We have ignition sequence start. The engines are on. Four, three, two . . ." Cronkite added, "She's building up and you can see the fire."

"Coming off, we have commit. We have liftoff," said King.

"She's clearing the tower, on a bright tower of flame," said Cronkite, his voice now resounding with emotion. "We're getting the shaking; the tremendous blast is hitting us now," he shouted, struggling to be heard over the roar. "She's going straight; she's in the roll program; she's looking good—a bright sapphire flame! Seven and a half million pounds—they're on their way!"

NASA

A TRIP TO THE MOON

Every voyage begins as a question. When the destination is the moon, the questions number in the millions—and the answers can be maddeningly elusive.

by Kenneth F. Weaver

PHOTOS COURTESY NASA

Methinks it were an easy leap to pluck bright honor from the pale-faced moon.
—Hotspur, *King Henry IV*

Orbiting above the moon at 3,700 mph, the little black and gold space bug named *Eagle* drew gently away from the command module *Columbia*. While *Eagle* pirouetted slowly, astronaut Michael Collins in *Columbia* confirmed that the bug's spindly legs were locked in place.

"*Eagle* has wings," exulted astronaut Neil Armstrong as he and fellow crew member Edwin "Buzz" Aldrin began the last portion of Apollo's lunar odyssey—what the French newspaper *Figaro* called "the greatest adventure in the history of mankind."

On the far side of the moon, temporarily out of radio contact with mission control in Houston, Armstrong fired his descent engine, putting the lunar module into a curving, computer-controlled descent.

At 50,000 feet, blinking lights on *Eagle*'s computer display signaled that it was time for the go/no go decision. Armstrong did not hesitate. *Eagle,* braking itself on a tail of flame, plunged into an ever steeper path toward the Sea of Tranquility.

At 33,000 feet, computer alarms sounded aboard *Eagle,* indicating the computer was receiving more information than it could process. Mission control reassured the startled astronauts.

At 500 feet the two men got their first close-up look at the target. What they saw set their hearts pounding: a crater littered with boulders instead of

On July 16, 1969, Neil Armstrong, Michael Collins, and Buzz Aldrin (left) were sent into Earth orbit atop the 36-story Saturn V (right). Collins described the sensation of liftoff as "like a nervous lady driving a wide car down a narrow alley."

When photographed two and a half minutes after liftoff, Apollo 11 had consumed 4.5 million pounds of propellant and was moving at 9,000 feet per second (right). The launch was monitored at 450 consoles at Cape Kennedy (above).

the smooth plain they had expected. Armstrong seized manual control and searched for a suitable landing spot.

But another crisis was in progress. At 160 feet a flashing red light warned that *Eagle*'s descent engine had only five percent of its fuel remaining. Mission rules dictated that the crew would have to abort if they were not on the surface within 94 seconds.

Astronaut Charles Duke, capsule communicator in Houston, began a countdown. "Sixty seconds," he marked.

Aldrin's deadpan voice read off progress data. "Down two and a half [feet per second]. Forward, forward. Good. Forty feet [altitude], down two and a half. Picking up some dust."

"Thirty seconds," warned capcom. Thirty seconds to failure.

With less than 20 seconds left, Aldrin called: "Contact light!" Moments later, Armstrong announced: "Tranquility Base here. The *Eagle* has landed."

Time: 4:17:43 p.m., EDT, Sunday, July 20, 1969. Not quite 103 hours had elapsed since Apollo 11 had lifted off from Cape Kennedy's Pad 39-A. The 21st U.S. manned spaceflight had accomplished the first half of President John F. Kennedy's goal.

When Kennedy called on Congress to fund a flight to the moon and back, the United States had logged a grand total of 15 minutes of manned spaceflight. In the face of this extraordinary goal, figuring out how to get to the moon and back became an early priority. It was no surprise that NASA's first major Apollo contract was awarded for the spacecraft's guidance and navigation system. There could be no margin for

error in the navigation of a spacecraft "attached to earth by such tenuous bonds as radio waves and star sights," as Charles Lindbergh would later write about Apollo. "A minor functional error would leave it floating forever in the space from which, ancestrally, it came."

To find a path to the moon, in 1961 NASA chose the Massachusetts Institute of Technology's Instrumentation Laboratory. Charles Stark Draper had established a towering reputation over the course of many years there for his work on inertial guidance systems. Undaunted by the task of getting to the moon, he assured NASA that it would be easier than guiding an anti-ballistic missile or circumnavigating the earth underwater in a nuclear submarine.

"It didn't look like anything but state-of-the-art engineering," remembers David Hoag, the laboratory's technical director for Apollo. "Of course, it turned out that we did go beyond the state of the art."

NASA still had misgivings. Barely a month after the contract was signed, NASA administrator James Webb summoned Draper and asked if he could really get a man to the moon and back. A pilot and aeronautical engineer, Draper told Webb that he would volunteer to make the first flight himself if NASA would guarantee the propulsion.

Draper and his staff set to work. The momentousness of the task soon caught up with the engineers: "Once we got started we knew we were unavoidably sharing a path going somewhere dramatic," says Hoag. "Either we would give up, fail, or succeed . . . . Thank God it was a good ending."

Draper's laboratory had produced the technology for the Navy's Polaris missile guidance, which provided a starting point for getting to the moon. A device conceived by Draper and known as an inertial measuring unit served as a reference point in space. Consisting of a suspended platform holding three gyroscopes mounted so that each one sensed movement around one of the three axes of rotation, this "stable table" would sense any change in the spacecraft's direction and notify the computer to make corrections by firing thrusters. Three accelerometers on the platform would also keep tabs on the spacecraft's acceleration in the three axes of motion.

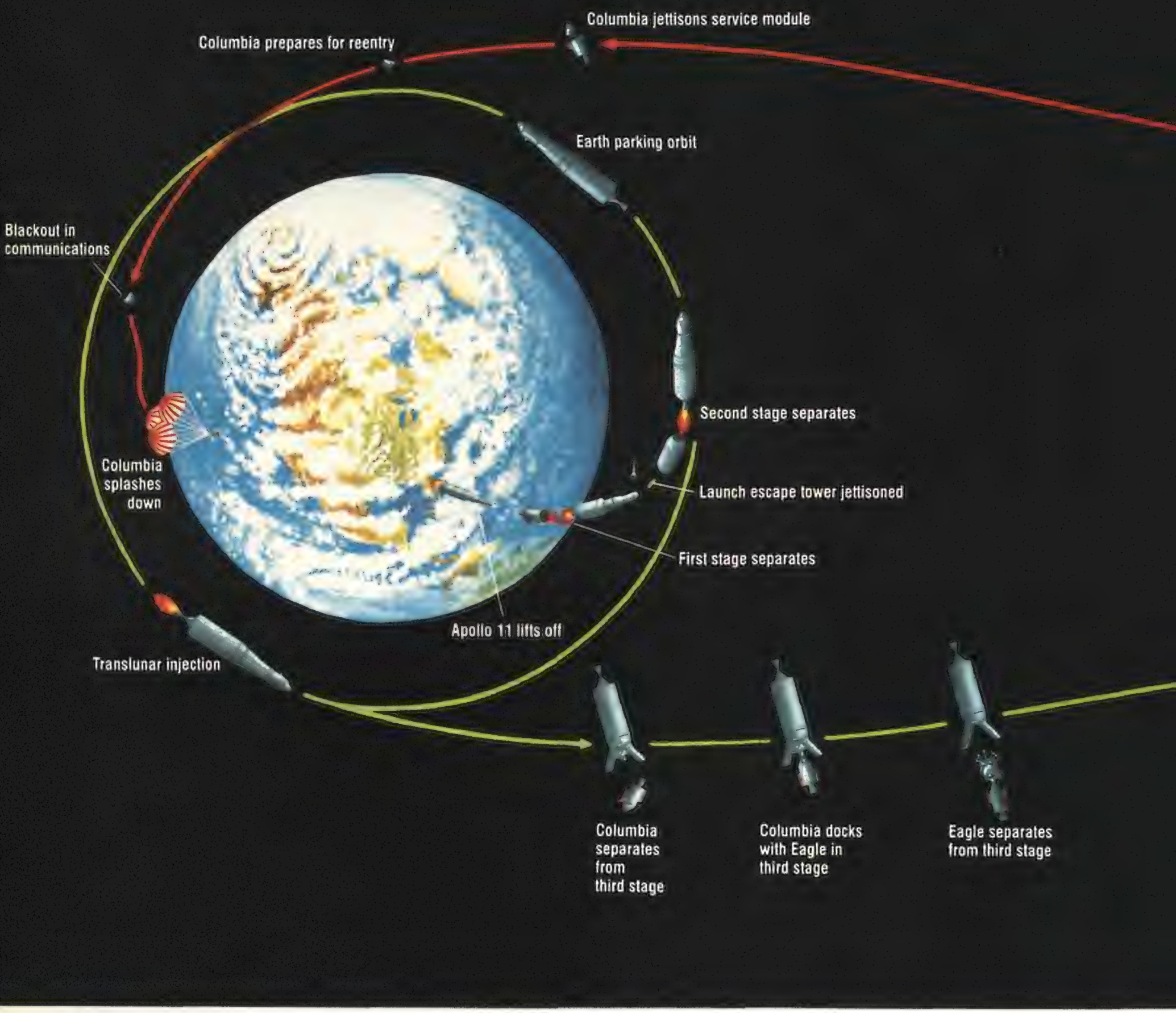
To assure that the inertial guidance system was working properly, command module pilot Michael Collins would make sextant sightings. A huge computer at mission control would also provide updates. In addition, a worldwide tracking and communications network consisting of 15 ground stations, four Navy ships, and a half-dozen aircraft provided data.

An onboard computer—the fourth crew member— would also handle a lot of the guidance and navigation, even though it had but a tiny fraction of the power of today's desk-top models. The numbers would begin to seem endless to the crew, and without the computer's ability to execute algorithms and make calculations, getting to the moon would have been impossible.

For the astronauts, the three-day trip from Earth orbit to lunar orbit was largely uneventful. Housekeeping chores filled some of the time: dumping wastewater, chlorinating drinking water, purging the fuel cells Apollo relied on for power. And instruments, switches, and circuit breakers all needed monitoring.

As they neared the moon, its image filled three-quarters of the hatch window. After the craft had traveled nearly a quarter of a million miles and the moon had moved in its orbit by some 200,000 miles, Apollo needed to adjust its course a mere 300 nautical miles. The flight plan had called for four course corrections on the outbound journey. But the guidance system had performed so marvelously that only one small correction—a three-second burst of the service propulsion engine—was required. After Apollo fired its engine again for insertion into lunar orbit, the

Former president Lyndon Johnson (with Lady Bird and Spiro Agnew) was on hand to watch the liftoff.



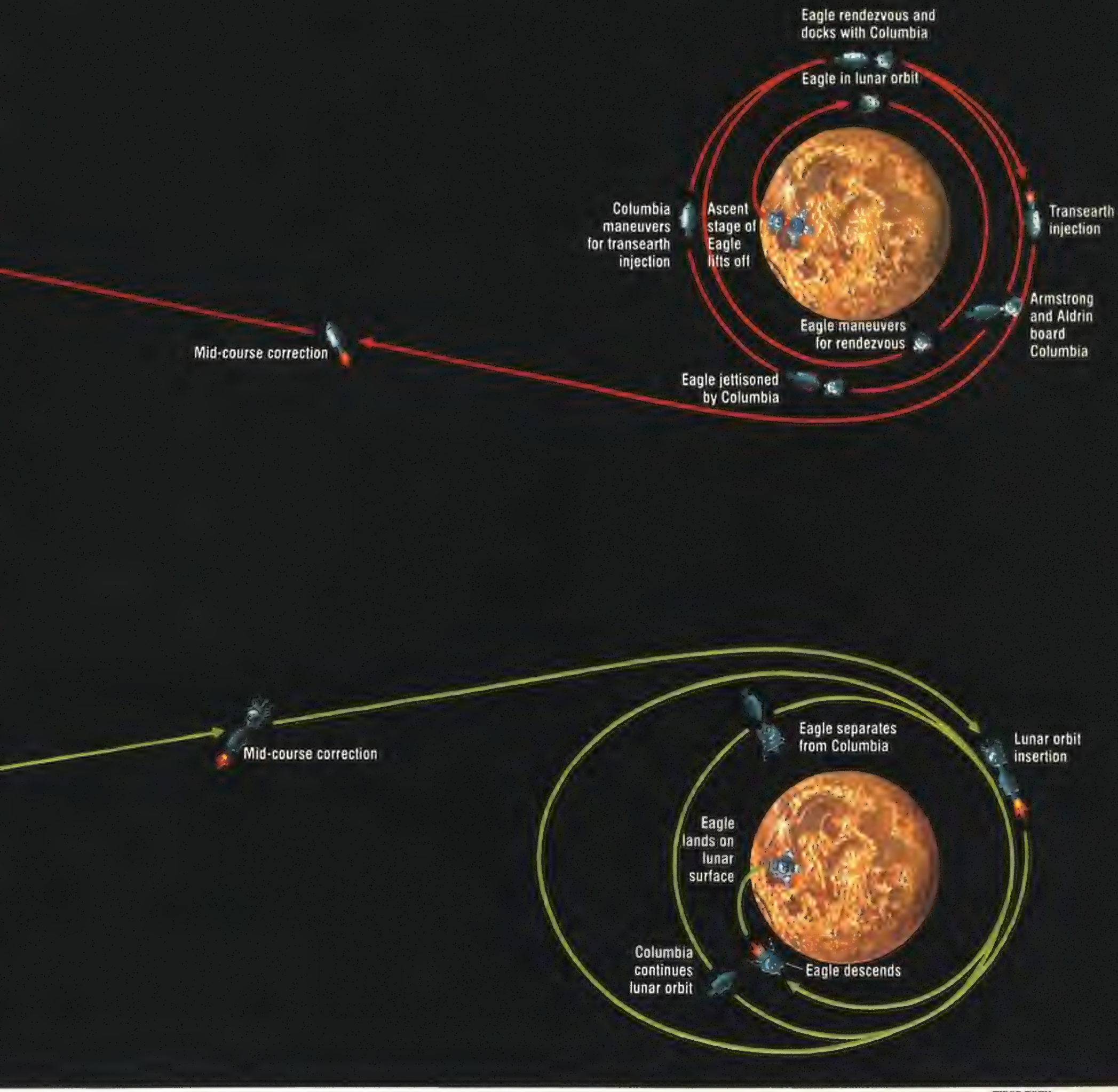
ship's velocity was off by only 1/10 of a foot per second out of a total velocity of 3,000 feet per second.

Apollo commander Armstrong glanced out the window of the lunar module at the moonscape. Depending on the angle of the sun, the lunar surface appeared either gray or tan. In the lunar sky, Earth loomed above. Six and a half hours after *Eagle* had landed on the Sea of Tranquility, the astronauts pulled the hatch open and Armstrong backed carefully down its ladder and stepped onto the barren, dusty surface. His historic words flew to the Honeysuckle Creek antenna near Canberra, Australia, then to the Comsat satellite over the Pacific, and then to a waiting world:

"That's one small step for man, one giant leap for mankind."

Armstrong had been preceded to the moon's surface by more than a dozen unmanned U.S. spacecraft. Known as Ranger, Surveyor, and Lunar Orbiter, they provided assurance that astronauts could, indeed, land and set foot safely on the moon.

In the early days, planners for a moon landing worried about a treacherous lunar surface. Would moonfarers plunge through hidden lava tubes? Or, as one scientist suggested, would moondust on



TIBOR TOTH

the spacemen's boots burst into flame when it encountered oxygen in the landing module?

NASA assigned the Jet Propulsion Laboratory in Pasadena, California, to answer these questions. What evolved was a kamikaze-like scientific mission. A giant dragonfly of a spacecraft named Ranger would deliberately crash into the lunar surface, transmitting pictures of the moon during the last 20 minutes of its mission. Such close-up information about the moon's surface was vital in determining where—or indeed whether—men could safely land.

JPL was the site of the most advanced satellite technology. But three years of Ranger failures would threaten the possibility of a manned visit to the moon.

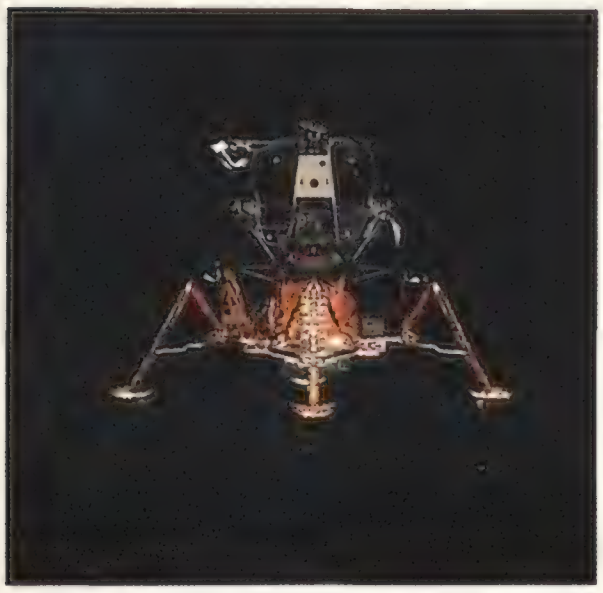
In August 1961, Ranger 1, after a host of troubles, burned up in Earth's atmosphere when the new Agena B upper stage failed to propel it out of Earth orbit.

Ranger 2, in November 1961, ditto.

Ranger 3, in January 1962, missed the moon by some 23,000 miles due to guidance system failure.

Ranger 4 hit the moon in April 1962, but a failed computer timer prevented it from responding to commands.

Ranger 5 lost power and missed the moon by 560 miles in October 1962.



Collins orbited the moon alone in Columbia *(top). During each orbit he was on the moon's far side for 48 minutes and thus out of communication. Armstrong and Aldrin descended to the moon in* Eagle. *They were scheduled to sleep after landing but preferred to explore.*

After each mishap there was a pause for investigation, research, and design modifications.

By the time of Ranger 5's disaster, the press was calling the Ranger program "Shoot and Hope." JPL's management was under fire, and inquiries were being made. NASA convened a failure review board, which uncovered weaknesses in both the design and testing of Ranger. A shake-up in management led to new operating procedures and tighter controls.

The failures were, of course, keenly disappointing to the hundreds of young engineers at JPL who had been putting in 12-hour days and six-day weeks for

months on end. "They expected it to be as easy as building a car, and it wasn't that simple," says Robert Crabtree, systems test and launch operations manager at JPL. The new procedures involved vigorous ground testing to increase reliability, detecting and replacing unreliable parts, simplifying systems, and duplicating critical elements.

"We learned the importance of redundancy," says Crabtree. "Components must have backups to insure reliable operation. We saw that elaborate ground testing was needed in the environment of space—thermal vacuum, heavy vibration, and so on. And we improved our quality assurance by more thorough inspections and reviews by outside experts." Redundancy was added to electronic circuits and test procedures were tightened.

In February 1964, Ranger 6, redesigned with additional backup systems, landed on the Sea of Tranquility. Unhappily, its TV cameras did not work. As the Atlas-Agena-Ranger vehicle was soaring through Earth's upper atmosphere, the high-voltage power supplies of the TV system apparently were inadvertently activated during the brief interval when low atmospheric pressure made it possible for them to destroy themselves by high-voltage arcing. This failure brought sharp new criticisms and new inquiries.

Five months later, on the morning of July 31, 1964, the Ranger project staff waited in a large windowless three-story building called the Space Flight Operations Facility. If all went well, television pictures would be received by a tracking station some 150 miles away in the Mojave Desert. "Everybody was on the edge of their chairs," remembers technical staff member Robert Steinbacher, who was operating a back-up recording camera at the time. "We had been taxed pretty well mentally and physically." Listening via intercom, the staff heard shouts as images of craters started to appear on television monitors at the tracking station. Inside the Space Flight Operations Facility "the place just went wild with pandemonium," says

Eagle*'s shadow looms over Armstrong as a television camera captures his first step on the moon.*

Aldrin makes his way down Eagle*'s ladder on the way to the "magnificent desolation" of the moon (top).*

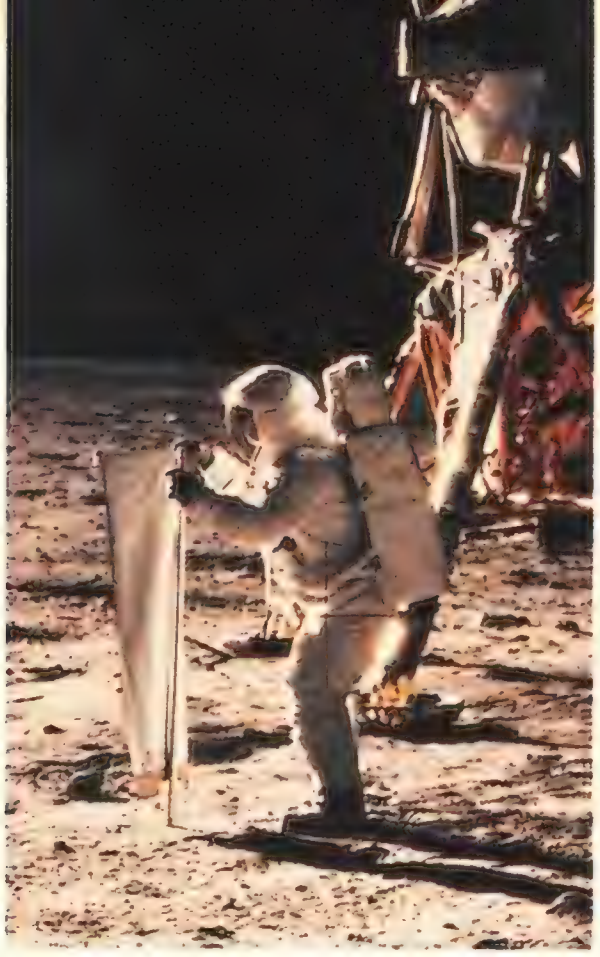
Armstrong made his historic first step onto a surface he described as "fine and powdery."

Steinbacher, as hundreds of engineers savored the triumph.

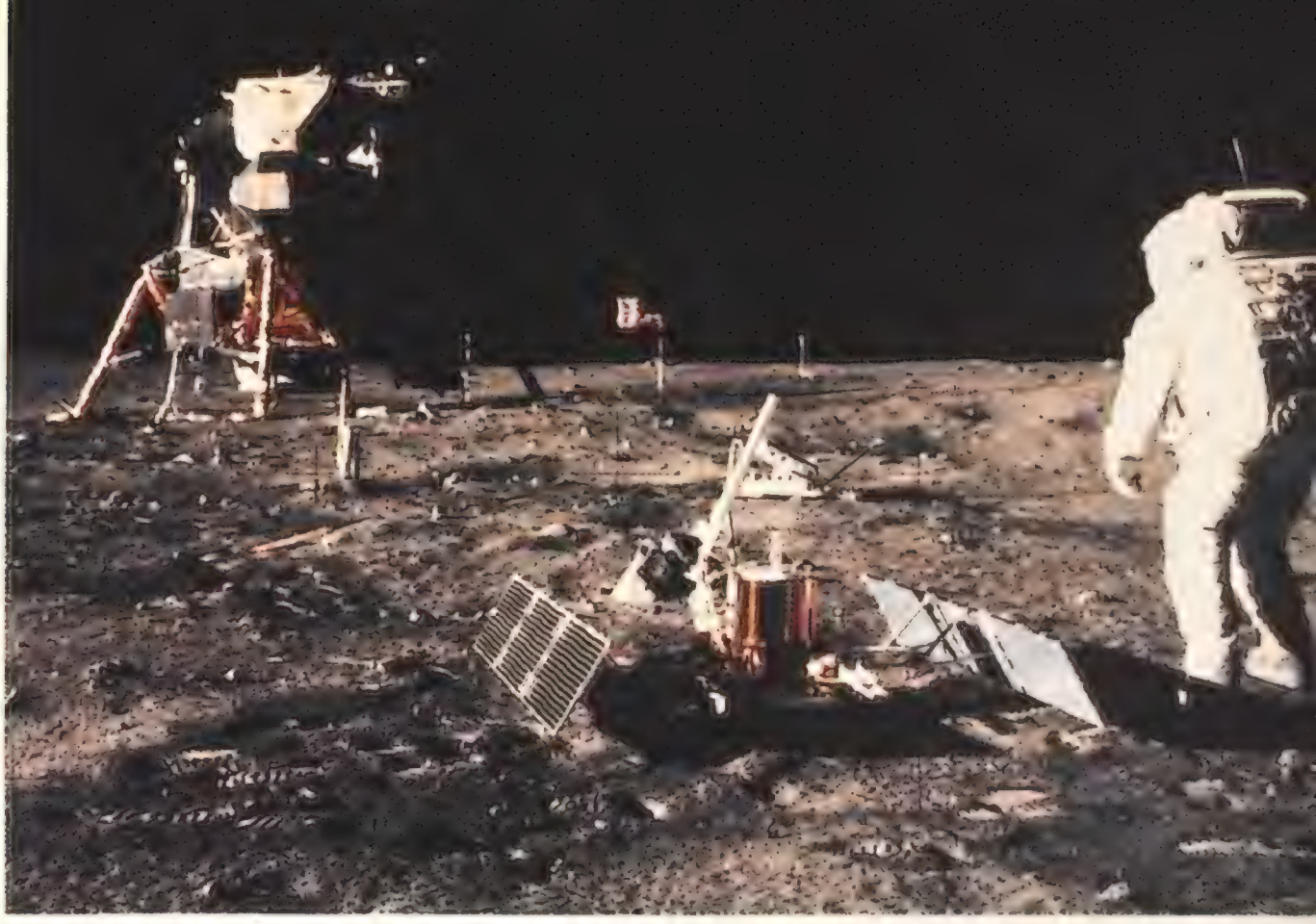
More than 4,300 black-and-white pictures were transmitted by the six TV cameras aboard Ranger 7 before it crashed into the moon. Resolution was as much as 2,000 times higher than earth-based photographs could provide. The next year, Rangers 8 and 9 beamed back nearly 13,000 additional pictures, many of them of the Sea of Tranquility.

Garbed in multi-layered spacesuits with self-contained oxygen and cooling systems, Neil Armstrong and Buzz Aldrin explored the "magnificent desolation" around them. They frolicked in great loping strides in the moon's one-sixth gravity, collected some 50 pounds of rock and soil to bring back, planted the American flag, and set up some scientific instruments.

Sixty nautical miles above in the command module, Michael Collins was circling the moon every two hours. When he received word from mission control that his crewmates on the moon had reentered *Eagle,* his response to Houston was "Hallelujah." Collins' greatest fear had been that Armstrong and Aldrin would be stranded on the moon. Now, after two hours and 20 minutes outside the lunar module, Armstrong



On Earth, Aldrin's spacesuit and its portable life support system weighed 180 pounds. Its moon weight was 30.



The astronauts' experiments included a seismic package sensitive enough to detect their footfalls.

and Aldrin were back inside. But before *Eagle* could rendezvous it had to get off the lunar surface. This would hinge on an ascent engine—an engine for which no backup had been constructed in the event of failure.

A triumph of function over form, the gawky lunar module consisted of an upper (ascent) stage and a lower (descent) stage. During liftoff from the moon, the descent stage would become the launch platform for the ascent stage. Other lunar modules had been tested on Apollos 9 and 10, but *Eagle* would be the first lunar module to actually lift off the moon.

NASA had hired Grumman to build the lunar module back in 1963. Located in the booming postwar suburbs of Long Island's Nassau County, Grumman had won its reputation building Navy fighters. But tardy decision-making on NASA's part had kept Grumman behind schedule from the start.

Playing catch-up in a race against the decade's end, the developers of the lunar module had been plagued by a seemingly endless number of technical problems. In addition to structural cracks and broken wiring, the lunar module had a weight problem. Despite walls that were so thin astronaut Jim McDivitt called it "the tissue-paper spacecraft," the lunar module kept getting heavier.

Another troubling problem was ascent engine instability. Eventually the problem was traced to unstable combustion due to the fuel injector. After a succession of ground tests and management overhaul, NASA felt comfortable enough to proceed.

Ground testing eventually gave way to an unmanned test in 1968. LM-1 performed so well that its successor's test was canceled and LM-2 was donated to the National Air and Space Museum. Only months before the scheduled lunar landing, LM-3 practiced docking during the Apollo 9 mission in March 1969. Two months later, LM-4 descended to within 50,000 feet of the lunar surface on the Apollo 10 mission.

LM-5 would be *Eagle*. It was ready on time and proved just as successful as its predecessors: seven minutes after liftoff from the moon, Aldrin and Armstrong were in lunar orbit.

Still ahead was the rendezvous, considered the biggest unknown by the engineers involved in planning the lunar landing mission. The strategy for rendezvous in space was based on an obscure art called orbital mechanics. It was a long way from the stick-and-rudder school of flying that most astronauts had on their résumés.

Rendezvous is a paradox: according to Kepler's Second Law, one must slow down in orbit if he wishes to speed up, and speed up to slow down. Thus, if an orbiting spacecraft fires its braking thrusters, it drops into a lower orbit and then automatically speeds up. If it fires its thrusters to increase its forward speed, the vehicle rises to a higher orbit and inevitably slows down. And if a spacecraft does not balance these topsy-turvy forces correctly it could easily run out of fuel and never reach its goal.

To prove the feasibility of the rendezvous concept, NASA sent Gemini spacecraft on repeated rendezvous missions. In 1965, Gemini 3 developed maneuvers to alter the plane and size of an orbit. Gemini 6, chasing Gemini 7 in late 1965, made the first rendezvous, at an altitude of 185 miles and a speed of greater than 17,000 mph. The five remaining Geminis continued to refine rendezvous and docking, using an orbiting Agena vehicle as a target. Both Gemini and Apollo pilots also used simulators to make hundreds of practice rendezvous, with computers throwing all kinds of malfunctions in their way.

Tutoring the astronauts in the intricacies of rendezvous theory was one of their own. Before joining NASA, Buzz Aldrin—Dr. Rendezvous to his fellow astronauts—had returned to the classroom, spending several years doing graduate work in orbital mechanics at MIT in the early 1960s. He had chosen this field of astronautics because he thought it would help get him a seat on a Gemini mission. He attained his goal, sharing the last Gemini mission—Gemini 12—with James Lovell.

Rendezvous theory had to pay off for Apollo 11. Aboard the mothership, Collins had a "cookbook" with 18 recipes for rescuing *Eagle* in case anything went wrong during rendezvous. Fairly small deviations in the trajectory could cause the lunar module to crash back

Their moonwalks over, Armstrong and Aldrin blasted off in Eagle*'s ascent stage to rejoin Collins.*

One hundred ninety-five hours after liftoff, Apollo 11 fell to Earth 900 miles southwest of Hawaii.

into the moon or fly a "dead man" curve—an aimless trip across the lunar sky and far out of range of the command module's rescue capability.

Columbia's ranging device picked them up at 250 miles. Then Collins, through his sextant, spotted *Eagle*'s tracking beacon, a tiny blinking light against the blackness of space. For the next three hours *Eagle* performed a series of maneuvers with its thruster jets, speeding up and slowing down to change orbital paths until it was aligned with *Columbia* and overtaking it. As it approached, Collins saw the lunar module's ascent stage as "a visible bug, glid-

New York City welcomed the Apollo 11 crew with its largest tickertape parade until the one for the '69 Mets.

ing golden and black, across the crater fields below."

The two craft partially joined and the docking seemed to be going well when *Eagle* veered violently and threatened to wrench free. "Instead of a docile little lunar module, suddenly I find myself attached to a wildly veering critter that seems to be trying to escape," Collins wrote in his account of the mission. He wrestled his hand controller until the latches connecting the two spacecraft caught with a bang and the danger was over. Apollo could now begin its homeward voyage.

The long coast back to Earth was as textbook-perfect as the outbound trip. At times the crew would simply bask in the Earthshine that lit their cabin and let Isaac Newton do the driving. Only one mid-course correction was necessary. Apollo hit its narrow atmospheric corridor faultlessly at 25,000 mph and endured the fiery furnace of reentry. When the three intrepid explorers set foot on the recovery ship *Hornet,* they brought with them "bright honor from the pale-faced moon."

It was an honor they shared with untold numbers of their fellow citizens, for as President Kennedy had said, " . . . in a very real sense it will not be one man going to the moon—it will be an entire nation, for all of us must work to put him there." Twenty manned flights had preceded Apollo 11—six Mercury, 10 Gemini, and four Apollo—and paved the way for the moon landing. Apollo 11 was, in fact, the distillation of effort by some 430,000 people: workers for 20,000 contractors and for scores of universities and laboratories, as well as hundreds of administrators and engineers at NASA itself. Costing eight years' time and $24 billion, Project Apollo was the greatest mobilization of men and resources for any peacetime endeavor.

If the leap of Apollo 11 seemed almost as easy as the one imagined by Shakespeare's Hotspur, it was only because hundreds of thousands of dedicated Americans helped make it so.

MEANWHILE, BACK ON EARTH

Where were *you* on July 20, 1969?

by Charlotte Evans

While two citizens of Earth, Neil Armstrong of Wapakoneta, Ohio, and Buzz Aldrin of Montclair, New Jersey, were paying the first visit to another celestial body, some three billion others toughed it out on *terra cognita.*

One in four went about his business unaware of what was happening a quarter of a million miles away—the governments of China, Albania, North Korea, and North Vietnam chose not to broadcast the news. About 600 million others, a fifth of the world's population, caught the moonwalk live on television.

Others knew about the event but weren't permitted to follow it. Nightshift workers at Western Electric distribution centers across the nation walked off the job after the moonwalk, angry at not being allowed to listen to radio reports of the mission. At Sing Sing maximum security prison in Ossining, New York, the warden ruled that inmates could watch television only during the normal viewing hours, which excluded the actual moonwalks.

Still, the news got through to some surprising quarters; even at Sing Sing, the one man on Death Row was allowed to watch as long as he liked. And in the Ghana village of Dodowa,

local chief Nagai Kassaull got the news via the Voice of America. He marveled, "The moon is so small, as I see it, that I didn't think there would be room enough for *Eagle*."

The walk raised other practical concerns. Viola Armstrong, mother of the Apollo 11 commander, confided, "I was worried that the moon might be too soft and that he would sink in too deeply." And Sammy Kaye observed that he could never have written his 1940s hit song "Moon Dust" in 1969. "I don't think dust sounds romantic now," he said, "and I can't look at the moon as a romantic place after seeing those craters and boulders and temperatures of 350 degrees."

It may not have inspired art, but the mission did inspire its share of commerce. One full-page ad in the July 21 *Houston Post* read: "Houston Control, this is Apollo 11 . . . there's no sign of life here except a sign painted on a boulder that says: 'Jimmie Green Chevrolet has the best automobile service on planet Earth.' "

Others made more lasting use of the moonwalk motif. In Fife, Scotland, a baby born on the day of the walk was named Neil Edwin Michael, after the three Apollo 11 crew members. In Colombo, Ceylon, UPI correspondent José Segura and his wife named their baby Neil Armstrong Segura. And in Elliston, Ohio, Mr. and Mrs. Delmar Moon announced the birth of their son, Neil Armstrong Moon.

Reaction to the moonwalk spanned the whole emotional spectrum. A nightclub owner in Beirut interrupted a striptease act to announce to the audience, "We made it!" Pope Paul VI, peering at the moon through a telescope, hailed the "extraordinary and astonishing" flight, though he worried about the "idolatry" of state-of-the-art scientific instruments and the risk of being fascinated "perhaps even to the point of madness." But Janet Armstrong, for one, was keeping her composure. The "attractive brunette wife" of the Apollo commander didn't expect new fame to go to her head, reported the *Houston Post* (which went on to note that Mrs. Armstrong was wearing a navy and white striped jersey and white skirt at the time of her statement).

Some insisted they were not impressed. Artist Pablo Picasso flatly declared, "It means nothing to me. I have no opinion about it and I don't care." Folk singer Joan Baez went further. The moonshot "makes me sick," she said, going on to point out that her husband, David Harris, who had refused induction into the service, "has work to do in prison and I have work to do outside."

Mets victory

Top Grossing Films

(week ending July 23, 1969)

The April Fools
True Grit
The Love Bug
Romeo and Juliet
Goodbye Columbus
The Wild Bunch
Once Upon a Time in the West
How to Commit Marriage
Hard Contract
Oliver

Biloxi, Mississippi, post-Camille

Others were probably equally preoccupied that day. In Hyannisport, Massachusetts, Senator Edward M. Kennedy remained in seclusion following an accident two days earlier in which the car he was driving went off a bridge at Chappaquiddick, resulting in the drowning death of secretary Mary Jo Kopechne.

In the Middle East, Israeli and Egyptian forces fought a four-hour ground and air battle. For the first time since the six-day war of June 1967, the Israelis used jets to attack Egyptian ground installations in the Suez Canal area.

In Hempstead, New York, Joe Namath, the 26-year-old quarterback of the New York Jets, reported to the team's training camp after a six-week "retirement," bowing to the demand of National Football League commissioner Pete Rozelle that he sell his interest in Bachelors III, a Manhattan nightclub allegedly frequented by gamblers.

And there were those who would never hear the news. Scattered incidents claimed the lives of 16 U.S. soldiers in Southeast Asia that day.

Some were soon chafing to move on to other issues. On July 22 Republican senator Karl Mundt of South Dakota opined that "the great

Best Selling Novels

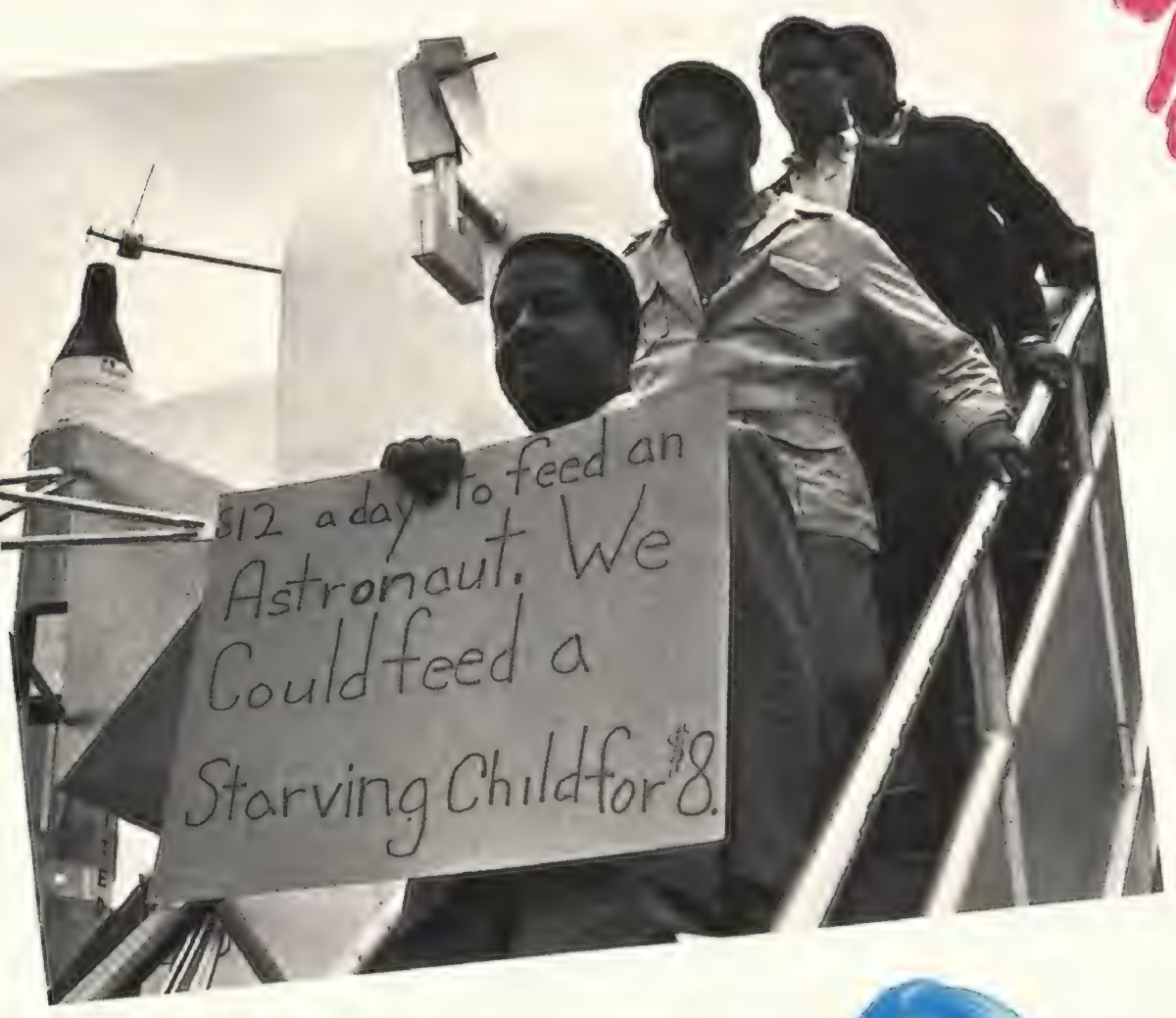
(week ending July 25, 1969)

The Love Machine (*Jacqueline Susann*)
Portnoy's Complaint (*Philip Roth*)
The Godfather (*Mario Puzo*)
Ada (*Vladimir Nabokov*)
The Andromeda Strain (*Michael Crichton*)
The Pretenders (*Gwen Davis*)
Except for Me and Thee (*Jessamyn West*)
Slaughterhouse Five (*Kurt Vonnegut Jr.*)
The Goodbye Look (*Ross Macdonald*)
The Vines of Yarrabee (*Dorothy Eden*)

Boeing 747

The war, at home and abroad

Reverend Ralph David Abernathy and others at Cape Kennedy



inventive genius of America which . . . put a man on the moon" was surely capable of producing a decent anti-ballistic missile system. Charles Evers, identified by the press as the "Negro Mayor" of Fayette, Mississippi, commented, "America needs to look at the earth, not at space. Before one more dollar is spent on outer space, we must make sure that not one child here on earth goes to a dinner table with no food on it."

Even Apollo 11 astronaut Michael Collins, heading back to earth, found his thoughts straying. How was the market doing? he asked mission control. He shouldn't have asked. According to an Associated Press report on July 22's trading, "The early upside flurry, in which the Dow Jones Industrials gained 1.61 in the first half hour of trading, was attributed to investor enthusiasm over the Apollo 11 moon mission. But the market turned then and headed down. At the end, it was off 11.90 at 834.02, a new low for the year." "Well," said Collins, "every flight has to have some disadvantages."

The day after the moonwalk, pollster Louis Harris reported that "[d]espite a substantial 62-32 percent favorable overall job rating, President Nixon is beginning to run into mounting criticism of his administration's performance on specific domestic issues, including

Betty Friedan

Liz and Dick

racial problems, college demonstrations and keeping the economy healthy." Eighty-two percent of those polled said the president "is really trying to get peace in Vietnam," but 60 percent said he "tries to be on all sides of every question."

No matter how weighty the issues were that summer, it was still summer, the season of distractions.

Three days after the moonwalk, the National League team rolled past the American League 9 to 3 in the 40th All Star Game, with help from Willie McCovey and Johnny Bench. (Vice President Spiro Agnew shook hands in the winners' clubhouse.) Meanwhile, in baseball that mattered, Chicago led the National League East, Atlanta the National League West, Baltimore the American League East, and Minnesota the American League West.

Another national pastime was the subject of *Time*'s July 11 cover story. In "The Sex Explosion," the newsweekly concluded that an "erotic renaissance (or rot, as some would have it) is on the land. Owing to a growing climate of permissiveness—and the Pill—Americans today have more sexual freedom than any previous generation. From stage and screen,

Chappaquiddick

Nixon Remembers

For me the most exciting event of the first year of my presidency came in July 1969 when an American became the first man to walk on the moon. The moon landing was the culmination of a program begun a dozen years earlier after the Soviets launched Sputnik, the first man-made orbiting satellite. American public opinion was jolted at the thought of the Soviets in control of outer space, but Eisenhower and most of his advisers were not so disturbed. Sherman Adams, for example, told a predominantly Republican audience that the so-called satellite race was just "an outer space basketball game." I believed that this flippant remark was wrong in substance and disastrous in terms of public opinion. The next night I told an audience in San Francisco, "We could make no greater mistake than to brush off this event as a scientific stunt of more significance to the man in the moon than to men on earth."

In Cabinet and NSC meetings during this time I strongly advocated a sharp increase in our missile and space programs. Eisenhower finally came around to this view and approved a proposal for manned space vehicles. While he justified this decision on military grounds, I felt that something far more basic was involved. I believe that when a great nation drops out of the race to explore the unknown, that nation ceases to be great.

The manned space program was already well under way when President Kennedy captured the national imagination in 1961 by setting the goal of a moon landing by the end of the decade. President Johnson was an enthusiastic supporter of NASA, and under his administration the Apollo program made great strides.

I decided that when the Apollo XI astronauts actually landed on the moon, the occasion should be well and widely marked. Working with NASA officials, we made plans for a televised phone conversation from the White House to the moon. In addition to planting an American flag on the lunar surface, the astronauts would leave behind a plaque bearing our signatures and a message that read:

HERE MEN
FROM THE PLANET EARTH
FIRST SET FOOT UPON THE
MOON
JULY, 1969 A.D.
WE CAME IN PEACE
FOR ALL MANKIND

On Sunday night, July 20, Apollo VIII astronaut Frank Borman, Bob Haldeman, and I stood around the TV set in the private office and watched Neil Armstrong step onto the moon. Then I went into the Oval Office next door where TV cameras had been set up for my split-

printed page and folk-rock juke boxes, society is bombarded with coital themes." Said actress Shelley Winters of frontal nudity: "I think it is disgusting, shameful and damaging to all things American. But if I were 22 with a great body, it would be artistic, tasteful, patriotic and a progressive, religious experience."

That summer, patrons of the Stonewall Inn, a gay bar in New York City, broke into a riot when police attempted to roust them. The outbreak marked the first demonstration for gay rights in the United States.

The Sex Explosion's shock waves were even felt at Cape Kennedy. In a previous issue, *Time* reported that an investigator for the American Social Health Association, sent to the launch facility to measure the incidence of prostitution, quickly abandoned his search, assured by a profusion of bartenders and bellhops that professionals were unneeded given the abundance of eager amateurs.

Family life at the Cape suffered from other causes as well. "It's not a natural environ-

The last Corvair

Mamie Eisenhower at Dwight's funeral

Billboard's Top 10 Singles

(*week ending July 19, 1969*)

In the Year 2525 (*Zagar & Zagar*)
Spinning Wheel (*Blood, Sweat & Tears*)
Good Morning Starshine (*Oliver*)
Crystal Blue Persuasion (*Tommy James and the Shondells*)
What Does It Take to Win Your Love (*Jr. Walker & The All Stars*)
One (*Three Dog Night*)
Color Him Father (*Winstons*)
The Ballad of John and Yoko (*The Beatles*)
My Cherie Amour (*Stevie Wonder*)
Love Theme From "Romeo and Juliet" (*Henry Mancini & Orchestra*)

screen phone call to the moon.

Armstrong's voice came through loud and clear. I said, "Because of what you have done the heavens have become a part of man's world. And as you talk to us from the Sea of Tranquillity, it inspires us to redouble our efforts to bring peace and tranquillity to earth."

After a journey of almost half a million miles to the moon and back, Apollo XI landed less than two miles from the prearranged target about a thousand miles southwest of Hawaii in the Pacific Ocean. I was there to welcome the astronauts home. Because the mission's command module was named *Columbia,* I had asked the Navy band to play "Columbia, the Gem of the Ocean" as the astronauts stepped from the helicopter onto the aircraft carrier *Hornet*'s deck.

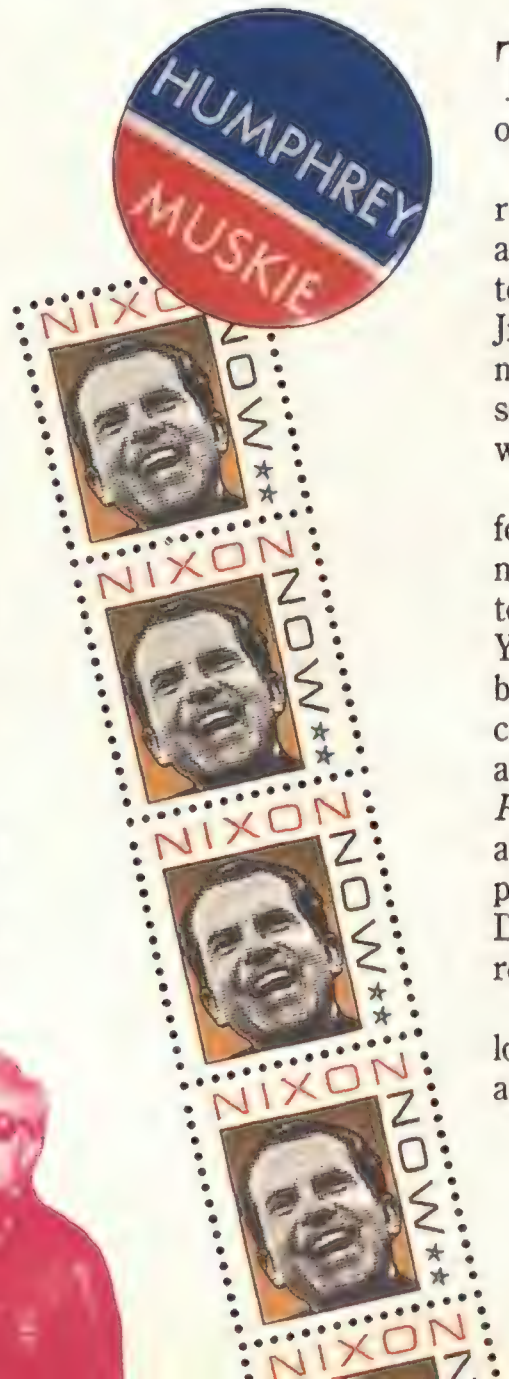
When I talked with them through the window of their quarantine chamber, it was hard to contain my enthusiasm or my awe at the thought that the three men on the other side of that glass had just returned from the moon. I said impulsively, "This is the greatest week in the history of the world since the Creation." When I talked to Billy Graham a few days later, he said, "Mr. President, I know exactly how you felt, and I understand exactly what you meant, but, even so, I think you may have been a little excessive."

The Apollo program ended on December 19, 1972, with the splashdown of Apollo XVII. By then, the public had become blasé about the ever-present hazards of space as well as the excitement of its challenge. The program had also begun to fall victim to the introverted attitude that threatened so much new technology in the 1970s. This contributed to the congressional refusal to support my proposal to continue our supersonic jet transport program, which I considered essential if America were to retain its lead in the field of commercial aviation. The argument went, as long as one person on earth is poor, not a dollar should be spent on space. In my opinion, however, exploration of space is one of the last of the great challenges to the American spirit. Space is perhaps the last frontier truly commensurate with America's capacity for wonder.

NASA

ment," one contractor told *Time.* "Down here you oversmoke, overeat, overdrink, overworry and undersleep." Circuit Court judge Volie Williams, discussing complaints by engineers' wives in 3,000 Cape divorce cases, observed: "The husband never wants any family life. He likes to build a stereo set from component parts and then dare anyone in the family to touch it. Every weekend he goes out in his boat by himself and doesn't want his wife or kids to go with him. He never physically abuses his wife and he's a good provider, but when he gives material things, he thinks he is fulfilling his obligations. He's selfish, but he doesn't think so."

Some unions endured, though. Harry Truman, 85, and his wife, Bess, 84, celebrated their golden wedding anniversary that summer. And Paul Newman and Joanne Woodward took out a half-page ad in the *Los Angeles Times* to respond to gossip columnist Joyce Haber's report that the two were "already living apart, according to friends, and will get a divorce." The ad read in part: "Terrified to disappoint Miss Haber and her readers, we will try to accommodate her 'Fascinating Rumors, So Far Unchecked' by busting up our marriage even though we still like each other."



Andy Warhol and Ultra Violet

The year, like every other, continued offering up events that in retrospect seem silly or ominous or simply odd.

Before the astronauts had returned, cigarette makers yielded to government pressure and agreed to stop advertising on radio and television by September 1970. Herbert L. Ley Jr., commissioner of the Food and Drug Administration, testified that "there is very little scientific evidence clearly linking a fatty diet with heart disease."

At week's end, *Time* hailed Jack Nicholson for his role in *Easy Rider,* and Texas congressman George Bush said he would wait until fall to say whether he would challenge Ralph Yarlborough for his Senate seat. "The crystal ball is very clouded," he said. "I am not discouraged, but it does not surprise me that I am not widely known in Texas." The *Houston Post* reported that Sharon Sites Adams, sailing alone for 74 days on a 5,618-mile trip from Japan to California, had arrived safely in San Diego. Under a picture of Adams ran a caption reading "Sailorette Arrives."

In early August, Charles Manson had his followers murder pregnant actress Sharon Tate and six others in Southern California. The fol-

Top Albums

(week ending July 30, 1969)

Blood, Sweat & Tears
Hair (*Original Cast*)
Romeo and Juliet (*Movie Soundtrack*)
This Is (*Tom Jones*)
A Warm Shade of Ivory
(*Henry Mancini & Orchestra*)
Crosby, Stills and Nash
In-A-Gadda-Da-Vida (*Iron Butterfly*)
Age of Aquarius (*Fifth Dimension*)
Tommy (*The Who*)
Nashville Skyline (*Bob Dylan*)

Jackie Kennedy and Aristotle Onassis

Andy Warhol painting

Folk singer Pete Seeger

lowing week, some 400,000 people converged on a dairy farm near Woodstock, New York, for a three-day concert featuring Canned Heat, Country Joe and the Fish, and sitar virtuoso Ravi Shankar, among others. A few days later, Hurricane Camille killed 256 people in Mississippi and Louisiana. In the middle of November a quarter of a million people opposed to the war in Vietnam staged a march on Washington. The next day, the 1968 My Lai massacre was revealed to the public.

One year after the Apollo landing, the Wapakoneta, Ohio *Daily News* ran a group of stories about hometown boy Neil Armstrong. Richard Brading, who had hired the young Armstrong as a delivery boy for his drugstore, was quoted as saying: "We hope that Neil can stop by more often now that he has a desk job in Washington and is not tied up with a vigorous training program."

The first man on the moon, however, was feeling less sanguine, if more philosophical. "I had hoped that [the mission] might take our minds away from some of the more mundane and temporal problems that as a society we face," confessed Armstrong. "I haven't seen as much evidence of this as I had hoped. We all seem to be sort of tied up with today's problems."

APOLLO LOG

Eugene Payne, *Charlotte Observer*, July 20, 1969

The control panel of the command module *Columbia* had:

- 24 instruments
- 40 event indicators
- 71 lights
- 566 switches

Typical meals for the Apollo 11 crew consisted of:

Breakfast: peaches, bacon squares, apricot cereal cubes, grape drink, orange drink

Lunch: cream of chicken soup, turkey and gravy, cheese cracker cubes, chocolate cubes, pineapple-grapefruit drink

Dinner: tuna salad, chicken stew, butterscotch pudding, cocoa, grapefruit drink

The first meal consumed on the moon included bacon squares, peaches, sugar cookie cubes, coffee, and pineapple-grapefruit drink.

The experiments Armstrong and Aldrin conducted on the moon's surface were:

- *Solar Wind Composition*: a sheet of aluminum foil that trapped particles of the solar wind to determine its elemental and isotopic composition.
- *Laser Ranging Retro-Reflector*: an array of fused silica cubes, which reflected a laser beam from Earth back to its point of origin. This provided precise measurement of Earth-moon distances, center of moon's mass motion, lunar radius, and geophysical information about Earth. It also had benefits for the development of space communication technology.
- *Passive Seismic Experiment Package*: three long-period seismometers and one short-period vertical seismometer for measuring meteoroid impacts and moonquakes and gathering information on the moon's mantle.
- *Lunar Field Geology*: the collection of lunar samples.

Frank Interlandi, *Los Angeles Times*, July 17, 1969

"Men on the way to the moon—can you grasp the full import of this moment in history?"

The litter left on the moon by Apollo 11 had a value of $1 million. It included:

- *Eagle*'s descent stage
- U.S. flag and staff
- The mast for the solar wind experiment
- The seismic package
- The laser reflector unit
- A 1 1/2-inch silicon disk containing messages from leaders of 73 nations
- A TV camera and tripod
- A gold olive branch symbolizing peace
- Two life support systems
- An Apollo 1 patch commemorating Virgil Grissom, Edward White, and Roger Chaffee
- Medals honoring cosmonauts Vladimir Komarov and Yuri Gagarin
- An equipment bag with cameras, tools, and other items

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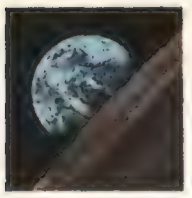


FULL-COURT PRESS: APOLLO MEETS THE MEDIA

In the beginning there was the Cape—and a handful of impressionable reporters. By the time Apollo 11 took off, NASA was hosting a large—and largely savvy—press corps.

As the media army at Cape Canaveral grew, the relationship between NASA and the press flowered. It has been said that the romance ended when the Challenger *exploded. But its beginnings can be traced back to the years leading up to Apollo 11. Three veterans of the space beat file their reports.*

FROM MISSILES TO THE MOONSHOT

by Howard Benedict
Associated Press

The first launch I ever covered was an Atlas missile test. The missile got off all right, but 30 seconds later it veered off course and disintegrated in a huge fireball. That was in 1959, after I'd just been named the Associated Press correspondent for Cape Canaveral. Doug Dederer, a gruff, hard-drinking reporter for a local newspaper, assured me I would see many more flights just like that one.

Doug was one of a handful of a new breed of reporters who had been covering the Cape for only a few months when I arrived. We were the first journalists assigned to cover a new beat: missiles and space. None of us had any formal training for the job because there wasn't any to be had. We learned by reading whatever literature we could find and by listening to the few engineers and scientists who dared to ignore the Air Force's advice to stay far away from the news media. In those days, the Air Force ran the place.

Crash programs had been pushed through to develop a family of U.S. missiles, including both ballistic and cruise missiles. But there were serious problems with both types. One day, a Polaris intermediate-range ballistic missile (IRBM) shot out of control and crashed into the nearby Banana River. We immediately renamed it an IBRM—an In the Banana River Missile.

Secrecy prevailed, but we learned that bartenders and motel clerks with a steady clientele of missile workers were good sources for scuttlebutt. Because it was such an us-against-them situation, we worked together and pooled information. There was a high, sandy knoll at the beach south of the Cape we called "Bird Watch Hill," and when a launch looked imminent we would assemble on top of it with our cameras aimed at the launch area. Of course, the Air Force didn't want us taking pictures of their missiles. Sometimes, just before liftoff, a helicopter would zoom in on the hill, hover to stir up the sand, and send us scurrying. By the time we recovered, the missile was either out of sight or at the bottom of the Atlantic Ocean—and we had no pictures. Mary Bubb from Fairchild would yell, "Damn you, Air Force!" at the departing helicopter.

Soviet spy boats disguised as fishing trawlers were standing offshore, monitoring launches on shortwave radio. If the Soviets could do it, why couldn't we? Once we had the radio gear, Jay Barbree of NBC, Al Webb of United Press International, and I agreed that whoever picked up a countdown would immediately alert the others. When we realized we were also picking up missile test results, we worried that we might violate national security concerns, so we decided to ask the Air Force about it. After long negotiations, some Air Force officials agreed to meet with reporters

every Friday and brief us on the launch schedule for the coming week. And—a major breakthrough—an observation site for the press was to be constructed at Cape Canaveral.

At the same time, the young National Aeronautics and Space Administration was beginning to assert itself at the Cape with an accelerating satellite program, and this new civilian agency brought a refreshing sense of openness to press coverage, as dictated by its charter. Until then, we'd had some difficulty explaining to the public the meaning of each failure or success. At first, we treated an exploding missile as just that: an exploding missile that scattered a lot of fireworks across the sky. Nobody ever told us what was going on or why a particular missile had failed. As we developed more sources we did a better job, and the new spirit of candor enabled us to do it more thoroughly.

On the evening of November 3, 1960, scores of revelers crowded around the pool at the Starlite Motel in the missile boomtown of Cocoa Beach, south of the Cape. They slugged down beer and stronger spirits, slapped one another on the back, sang songs, tossed chairs, tables, and each other into the water. A Juno rocket had successfully lofted a NASA satellite into orbit that night, which called for a massive celebration to let off some steam. Among the wettest and happiest was the launch director, Kurt Debus, who had once launched rockets for Adolf Hitler. That pool would become the unofficial venue for some bizarre ceremonies.

In a close-knit community of scientists, engineers, and technicians like the one that had populated Cocoa Beach, the small band of news people covering the program full-time became part of the scene. We knew the players well and

AP reporter Howard Benedict was among the first journalists on a new beat: missiles and space.

shared their disappointments and triumphs. When things went wrong, Doug Dederer could be counted on to be more blunt than most reporters. His paper, the *Cocoa Tribune*, was small, with limited circulation, and most missile people considered him a harmless gadfly.

But when Doug wrote after an Atlas failure that he would not shave until the missile scored a success—and then reported on the length of his beard after each subsequent failure—he angered B.G. MacNabb of the Convair Division of General Dynamics, who was the Atlas project director. Eventually, an Atlas was launched successfully, and that evening, the revelry around the Starlite pool was in full swing by the time Doug appeared. MacNabb and some of his workers took off after him, wrestled him to the ground, and took a razor to his beard.

In the summer of 1959 I spent three hours in a beachfront room at the Silver Sands Motel in Cocoa Beach listening to Wernher von Braun tell me how a rocket worked, how a satellite was placed in orbit, how it eventually died a fiery death in the atmosphere. We talked until midnight. This giant of a man, the preeminent German rocket scientist who had developed the Redstone into America's first ballistic missile and the booster for the first U.S. satellite, was one of my most prized mentors in those early days.

He distrusted the press because many publications had sensationalized, even ridiculed, his ideas. But if you could find a way to gain his trust, he instructed patiently and, as he demonstrated on that midsummer night, selflessly. He dreamed of humans flying into space, to the moon and beyond, and he recognized that through the press he could get to the public, which eventually would have to support such ventures. And he was charismatic. I got caught up in his dreams, as did many of my colleagues, and we helped push his agenda. I have no regrets about that.

One of von Braun's slender Redstones lifted off on May 5, 1961, and carried astronaut Alan B. Shepard briefly across the threshold of space—the first American to probe the new frontier. Shepard's flight electrified the country and inspired John F. Kennedy's bold challenge to land Americans on the moon. Our role as reporters began to change: the focus shifted from the military missiles and the fledgling satellite efforts; man in space, the race with the Russians to the moon—those were the stories. I remember Jay Barbree saying, "This is going to be a hell of a big story for many, many years."

The story of the race into space altered the landscape of space reporting. The handful of regulars at the Cape were reinforced from time to time by newcomers, and some with sources in Washington and in Congress would occasionally beat us on a political aspect of the story. But when it came to the nuts and bolts and the hardware of spaceflight, we who had been on the scene were hard to match.

Life *photographer Ralph Morse sampled simulated weightlessness on a 1962 airplane flight.*

ASSIGNMENT APOLLO

by Ralph Morse
Time-Life (retired)

In April 1959, I got a call from *Life* magazine's New York office asking me to go to Washington to photograph the NASA press conference where the first astronauts would be introduced to the world. That was the day they were asked, "How many of you guys expect to get back alive?" and all the astronauts raised a hand—except for Wally Schirra and John Glenn, who put *both* their hands up. I took a picture of that.

When I got back to the office I sat down and wrote a memo to the science editor suggesting that *Life* assign a single reporter and photographer full time to cover these seven guys. Wherever the astronauts went they would attract a press mob, and they would respond to the people who were with them all the time. Two or three months later *Life* gave me the assignment.

Throughout the space program I took pictures either for the press pool that operated up until the Apollo 11 mission or for *Life* magazine exclusively. The pool system, in which all the members of the pool share all the photographs they take, applied to all the photos taken on the Cape—except for those taken at

Fire in the cockpit! A chilling cry came from the Apollo 1 command module on a January afternoon in 1967. Three astronauts died as flames swept swiftly through the spacecraft on what was supposed to have been a routine launch pad test. I wrote with sadness about the deaths of three men I had known. But I also was highly critical of NASA and its contractors, questioning management and engineering judgments made in the haste to achieve the lunar goal.

Should I have asked those questions sooner, before three men died? Had my journalistic instincts been clouded by my enthusiasm for the adventure? NASA officials had admitted there were problems with the spacecraft, but there was nothing in their reports to hint at anything like the fire. To this day I wonder if I could have been more vigilant. And the *Challenger* disaster, coming 19 years later, has made me wonder anew.

NASA's long recovery from the fire had been crowned in October 1968 by the successful orbital flight of three astronauts in the Apollo 7 spacecraft. In early November, 12 of us met for lunch at Ramon's restaurant in Cocoa Beach, the home of the Canaveral Press Club. Each of us put $5 in a pot and wrote down the date he thought Americans would land on the moon. Only three picked a day in 1969. My choice: May 6, 1970—10 months late.

All bets were off a few days later when NASA announced that the next manned flight, Apollo 8, would use the Saturn V to hurl a three-man spacecraft into orbit around the moon. It was a bold stroke that would provide vital information about navigating to and around the moon, buy time while the lunar module was readied, and rob the Soviets of any glory they might reap by looping one man around the moon on a translunar trajectory; there was a widely reported rumor that the Soviets were ready to do just that.

Some of us questioned the wisdom of sending Apollo 8 around the moon. The Saturn V had never flown with a crew aboard, and the rocket's last unmanned test had revealed engine problems and a severe vibration. But NASA had faith in its testing, models, and computers. The daring mission was a huge, uplifting success, and two more Apollo flights set the stage for the main event: Apollo 11.

The press site was crowded on July 16, 1969, with nearly 3,000 journalists. Of these, hundreds were covering a launch for the first time and knew little about what was happening except that man was going to the moon. Some wrote about the most trivial matters. A tree in Mike Collins' yard in Houston made news when it was blown down by a storm the night before.

"They're going to botch up this monumental event," said Mary Bubb. "Why don't they just leave it to us who know what's going on?"

Then it was time.

Great clouds of burning fuel, orange in the gray-black smoke, billowed from the base of the rocket, almost right on the designated millisecond, at 9:32 a.m. I was in the press bleachers, dictating the running story to AP's space desk near the Manned Spacecraft Center in Houston. "Reaching for a dream . . . ," I began. I was choked with emotion. Not long ago, a lot of missiles were blowing up here and man-to-the-moon was the stuff of science fiction. Ten years of my life had led to this, and I joined in the cheering. I doubt that anyone will fault me for getting caught up in that grand moment.

the press site—and consisted of NASA, *Life, National Geographic,* AP, and UPI. The pictures were made available to anyone who requested them. Generally the photographers worked well together. We'd lend lenses back and forth, or borrow film and batteries from each other.

Because I had experience with remote cameras I was given responsibility for the remotes and the launch pad. We had to devise equipment constantly and have it jerry-built with Rube Goldberg contraptions.

Every time there was a mission delay, with the cameras sitting out in the hot Florida sun, we had to go out and replace the film because you never knew if the film was going to melt onto the pressure plate or something. Just to be safe, we'd replace the batteries and then set everything up again.

The number of remote cameras would vary with the launch. I've had a total of seven of my remote cameras burned up by launches: one during Apollo 7 and six during the first shuttle launch. For Apollo 7, I was trying to capture the engines' flames to illustrate that this was the first flight since the Apollo fire. I put two cameras flat on the ground underneath the rocket. One came through but the other burned up—it was an old camera, though.

At the time I photographed the original astronauts at their first press conference, I'd been working as a *Life* photographer for 17 years. Working for *Life* gave me one advantage covering the space program: the magazine had the best access to the families of the original seven astronauts. *Life* had purchased

PHOTOS BY RALPH MORSE, LIFE MAGAZINE, ©TIME, INC.

Reporters wondered which of the astronauts expected to return alive. This was their answer (top).

Virgil Grissom would have been the first to fly on Mercury, Gemini, and Apollo spacecraft (above).

Alan Shepard prepares to board his Mercury-Redstone—the shot Morse calls the best space photo ever (right).

an exclusive and controversial contract with the first seven. The decision created a lot of rancor in the press corps, although a lot of that was just sour grapes from those who had also bid for the contract. What a lot of people don't realize today is that the contract applied only to the astronauts' personal stories; it had nothing to do with the government part of the program. Whether the contract was right or wrong is still a question today, but when you're the biggest magazine in the world and the president of the United States has okayed something like that I don't see how you can turn it down.

The contract did help me get to know the families well, and I became friends with them. Sometimes we would play games to keep the rest of the press away. When Scott Carpenter was preparing to blast off for his orbital flight, his wife Rene decided she wanted to come to Cocoa Beach to watch. NASA didn't want her anywhere near the public, so she asked me to help her take care of things.

I arranged with the Navy to fly Rene and her kids to the Naval Air Station in Sanford, Florida. In Cocoa Beach I rented two houses—one was a backup in case the press discovered us—and stocked them with food. Then I rented three cars. I drove the first one to Sanford to pick up the Carpenters. Halfway to Cocoa Beach we changed cars, just in case we'd been spotted. Outside Melbourne we changed to the third car and when we neared the first house in Cocoa Beach we had all the kids hide on the floor so no one could see them.

Then Carpenter landed off course and

The families of Aldrin, Collins, and Armstrong posed with a rented moon that came three days late (top).

Morse helped Rene Carpenter and family, here watching Scott's orbital flight, to find seclusion.

John Glenn's successful first orbit of Earth made him a hero (top). He later left NASA for politics.

When Neil Armstrong's Gemini 8 mission aborted, wife Jan waited in anguish for word of the outcome.

was lost for a few hours. *Life* writer Loudon Wainwright and I were inside the house throughout the entire nerve-wracking period when no one knew if he had survived his reentry and things were very tense for Rene. Loudon wondered whether we should leave. I said, "We don't. We're here as the press, we don't leave, we stay and cover it. We make our apologies and stay." It was a pretty hairy time until they found him.

We needed some updated family pictures for the flight of Apollo 10. So I called John Young and suggested he have a steak cookout at his house one Sunday afternoon with the crew and families. He agreed.

Young lived directly opposite Tom Stafford. I knew that Stafford was building a rowboat in his basement from a kit so I asked John if we could launch the boat in his pool. We went over to the Staffords', brought the boat over, and put it in the pool. Then I had the three Apollo 10 astronauts, the next ones scheduled to orbit the moon, stand in the boat. And the damn thing went straight to the bottom.

I photographed all the Apollo 11 astronauts, too. I even took a picture of Neil Armstrong diapering his baby the first or second day he entered the program. The guys at NASA said that he'd never let me take the picture, that he wasn't that kind of a guy. But I was over at his house and I said, "Neil, you've got to diaper your baby for me. We've got to make you human." He did it.

For the Apollo 11 mission I needed a new picture of the Armstrong, Aldrin, and Collins families. I rented an eight-foot, high-fidelity globe of the moon from Doubleday in New York City and shipped it air freight to Houston, where the three families were living. I rented the ballroom of the Holiday Inn for the picture—but the airline lost the moon. We had to wait for three days until it finally showed up.

NASA wasn't always a help. There were some people in NASA who were excellent. But if you take NASA as a whole, I think they would have preferred it if we'd all stayed away. Once, when the astronauts were going out to Nevada to undergo survival training in the desert, the decision was made that there would be no press invited along. I decided to head out to Reno anyway.

I rented a Piper Cub and zigzagged around the desert until I saw these seven cloth Mercury capsules that had been built for the survival training. On the way to the airport I had stopped and bought four bags of flour. After I found the site I headed back to the road and bombed it with the flour bags to mark a trail. We went back into town, rented a Jeep, and followed our flour trail to the site. When the astronauts arrived the next day in their helicopter we were standing there with chef hats waiting to make them breakfast.

The astronauts were able to get me back, though. In the desert a few days later Alan Shepard came over to me and said, "Ralph, would you mind moving your Jeep? We've got a bunch of VIPs and generals coming out this morning." Even though we were in the middle of the desert I didn't stop to think that the new arrivals could just as easily park on the other side of the tent. I climbed into the Jeep, turned the key, and the car started billowing orange-yellow smoke.

Morse's posed photograph of Donald "Deke" Slayton with a test missile rising in the background exemplifies his talent for rendering the drama in the space program (top). His eerie shot of a subject being measured for a space helmet is pure art.

The astronauts had hitched a helicopter landing flare to it, and it was set off by the ignition. The whole Jeep got burned. We were afraid to go back to the rental company, so we waited until the place was closed for the night before we turned it in.

We called practical jokes like that "gotchas," and they became a constant element in the friendship between Wally Schirra and me over the years. At the time of Schirra's Apollo 7 flight, *Life* decided at the last minute that they needed a cover shot of him. I arrived at his house around 2:30 in the morning and woke him up for the session. I told him we'd frame one for him so he could put it in his study. The art department took the picture, cut out the eyes and put them back upside down, put a woman's lips on him, and turned his hair gray. Then we framed it in a beautiful frame and put it in his study. The only other people who knew about it were his wife and daughter. But Schirra didn't notice. Finally, about six weeks later, he said to me, "I couldn't figure out why every Friday night when I sat in my study to open the mail my daughter insisted on staying in the room with me. Finally one day I looked up, took one look at the picture, and burst out laughing. I almost fell over."

There was more interest in the Apollo mission than there is currently in the shuttle flights. With Apollo there was a progression—each mission was another step closer to the moon. I tried to communicate that with my pictures. I took one of Apollo 8 on the pad, and the Hayden Planetarium helped us place the moon in the picture in the exact location it was at the time of liftoff. Apollo 9 carried the first lunar module, and I went to Grumman and took a picture of the LM for a double exposure with the Saturn V. I did a similar photograph for Apollo 15 when it took up the lunar rover for the first time.

I think if anything can be said about the *Life* crew, it's that we were the forerunners. The guys covering the space program have it tougher now because it's all been done. There was a lot of interest after the *Challenger* disaster, but now a space shuttle launch is considered a routine story. When I was covering the space program, it was still fresh.

LIVE FROM THE CAPE

by Christopher Glenn
CBS Radio

In the early days at the Cape, everybody was so gung-ho, and the names Borman and Lovell were as familiar to everybody as Nixon and Agnew. There was a tradition on launch eve to invite the highest ranking NASA official that your organization could possibly lay its hands on to go to dinner with you. And you'd go to Bernard's Surf restaurant in Cocoa Beach and sit around in their black leather banquettes eating the exotic foods—they had one of those menus with buffalo meat and things like that—and you'd sit around there and try to be seen. If it was an astronaut, great. If it was the head of Rockwell engineering, terrific. You couldn't ask for more than that.

NASA people are basically very cooperative. It's the only place that I know in journalism where there are people literally sitting around waiting for you to stick a microphone in their faces. But

CBS

Correspondent Christopher Glenn of CBS Radio has been reporting on space since the launch of Apollo 10.

there's something about NASA folks: they'll tell you anything you want to know but they won't tell you anything. They're so nice and so cooperative, but if you throw a curveball question they'll get around it—very pleasantly, very nicely, but it's difficult to get hard information from them. You really have to be a full-time space reporter and make calls every single day of your life to really get in with these people and really have them primed so when something happens, they call you.

I was at Metromedia when I did my first Apollo mission, and in 1971 I moved to CBS. Metromedia didn't have a big building. They had a wonderful little trailer about twice the size of a table, and we were pretty cramped in there. For the launch of Apollo 10 I was the producer, and I could hear our anchor talking through the pre-ignition countdown. Then it was T minus zero and the Saturn started to lift off. I was standing there watching—I'd never seen this thing before. I heard him say the Saturn cleared the tower, and then the vibration hit us from three miles away. And all of a sudden we were off the air! Everything stopped—all the power—everything just went out. I thought, *Oh my God, what happened?* I was running around, flipping switches, wondering what the hell was going on.

The vibration had knocked the master electrical power plug out of the wall of the trailer. I stuck it back in, but we'd been off the air for about 15 seconds right in the middle of the launch.

I loved to watch the Apollos fly. The shuttle clears the tower in three seconds—literally three seconds after ignition, it's gone. But the Apollos would just sit there—slow, ponderous. You can't capture the way it actually sounds: it's a low bass. And you'd think, *This is not going to fly. If it ever gets off the pad it'll fall over.* And everyone was cheering, "GO! Up! Up!"

I was working during the Apollo 11 landing, but I was off for the moonwalk. I can remember my emotions, and people—the public emotions that day. It was just unreal. Out in Central Park all these crazies were dancing around, smoking dope, looking up in the sky. There was such partying, and I think everybody was just so thrilled by it. It truly was the way Walter Cronkite described it—a great historic day. It was a wonderful time. It was like a world hallucination except that it was real. It was everybody on the same wavelength for just a little while.

Today reporters are talking all in digits. And I've watched the press corps at the Cape shrink. They're very thorough reporters, they work a very specialized operation, and I think there's more specialization these days among the people who cover space. The general reporters would cover it on a regular basis, but they were not space reporters. They were there because they loved it, and they could do a good job.

I don't think there's a lot of confrontational reporting on space. I don't think there's been a lot down through the years. I don't know why.

In the Apollo days, there was a greater willingness [within NASA] to take risks, to solve problems on the fly. The old attitude was "We've got a problem and we're going to solve it." You don't see a lot of that attitude anymore. The barnstorming days are over, and I've noticed an air of caution on the part of NASA creeping in. It's kind of distressing.

After the Grissom-Chaffee-White fire, NASA responded by throttling back on its PR. But it started up again when civilians started getting involved. Of course, now they're off that altogether and the crews are thorough pros. You don't get that air-to-ground talk like you used to—there isn't the happy chatter anymore. It's strictly business these days, and it's probably a good thing. But they don't give you many sound bites, unless you want to hear them reading from data pads.

When the Apollo missions ended I was very disappointed. I couldn't believe it. All that excitement and more boosters sitting in the garage, and it just stopped all of a sudden. The whole attitude was "We're closing a book and putting it back on the shelf as if it never happened." You read the book and it was wonderful—and then it was over. And I have never understood that.

WHY HAVEN'T WE GONE BACK?

It's been nearly 17 years since the United States bid *au revoir* to the moon. Or was it goodbye?

by Andrew Chaikin

Apollo 17 astronauts Eugene Cernan and Harrison Schmitt left the moon's surface in December 1972. No one has been back since.

When Neil Armstrong, Michael Collins, and Buzz Aldrin emerged from their post-lunar quarantine in August 1969, President Nixon had them out to Los Angeles, along with a few hundred guests, to celebrate the triumph of the first lunar landing. According to those who were there, it was a hell of a party. Sometime well into the evening, one of the many astronauts attending the gala, by then more than a little drunk, raised his glass. "Here's to the Apollo program," he said heartily. "It's all over." It seemed a strange thing to say in that hour of triumph, just as the moon had been transformed from a light in the sky to a world ripe for exploration. And yet, in a sense, the astronaut was right.

A unique era in space exploration had ended. From 1961 to 1969 anyone could go outside at night and actually see our goal in space. But the moon lost that special status on that July evening when we watched two ghostly, space-suited figures dance in slow motion across the stark, bright surface of another world. John F. Kennedy's challenge to land a man on the moon before the decade was out had been met. Kennedy had never said anything about going back.

But we did go back, and for 41 short months an Age of Manned Lunar Exploration ensued as Apollo progressed at a spectacular pace. Each team of astronauts that reached the moon stayed longer, traveled farther, took more photographs, and collected more samples than its predecessors. On Earth, scientists analyzing the moonrocks began to decipher their ancient message, paging through the earliest chapter of a 4.6-billion-year history book. Then, in December 1972, the Apollo 17 lunar module *Challenger* lifted off the moon and brought the Age of Manned Lunar Exploration to what seemed then—and still seems—a premature end.

NASA had not intended to abandon the moon, but by 1969 it was already clear that Apollo would not carry the agency through the 1970s. Congress had voiced little support for a proposed Apollo Applications Program that would use Apollo hardware for space stations in Earth orbit, bases on the moon, and other missions until the next generation of spacecraft was ready. NASA managers realized that if the space program was to move forward, the expensive, throw-away craft like Apollo that went to museums after only one flight must yield to those with new attributes: permanence, reusability, economy. Apollo was a marvelous engineering achievement, but for NASA it had become a dead end.

The space agency's underlying assumption was that even as a dead end Apollo should be a jumping-off point. Since 1961 the country had built up extraordinary momentum in space, and it seemed unthinkable to let it just die out. Hadn't Kennedy intended the moon program to establish the United States as a spacefaring nation? Apollo 11 was more than a lunar landing; it was a demonstration that the country had achieved spaceworthiness. The way into the solar system was open, if the money could be found to go.

By the fall of 1969, NASA administrator Thomas Paine and his staff had formulated a plan that would take the United States into space to stay, back to the moon, and to the red dust of Mars. The plan itself had its roots in the early

PAUL DIMARE

CHESLEY BONESTELL

Chesley Bonestell rendered Wernher von Braun's celestial visions for Collier's *magazine in the 1950s (left). Today, NASA is struggling to bring that vision to life (above).*

1950s, when space travel was still considered fantasy. Back then readers of *Collier's* magazine had been presented with an astounding vision of space exploration mapped out in a series of articles by Wernher von Braun and other space experts. Chesley Bonestell's spectacular illustrations depicted winged space shuttles, wheel-shaped space stations, moonships, and Mars craft based on designs by von Braun and his rocket team. At the time, von Braun was criticized for trying to sell the public a science fiction vision of the future. Less than two decades later this was the vision that Paine hoped to make reality.

In retrospect the scenario Paine presented to the White House seems wildly optimistic. It called for the establishment of a 12-man space station as early as 1976, along with the debut of the space shuttle, followed by a station in lunar orbit, a base on the moon, and a 50-man Earth-orbiting space base. Then, as early as 1981, a manned expedition to Mars would depart from Earth orbit.

Paine knew at the outset that it was a long shot. Every year since 1965, when Apollo funding hit its peak, NASA's budget had declined. Lyndon B. Johnson, initially a strong space supporter, had become increasingly occupied with domestic troubles and the Vietnam War (a single year of which had come to cost as much as the entire Apollo program). Johnson left the decision about NASA's future to his successor, Richard Nixon.

As Paine recalls, Nixon had his mind on inflation and Vietnam, not the space program. "It hadn't gotten through to him," Paine says. "He'd enjoyed his overseas trips. He'd enjoyed going out to the carrier and watching Apollo 11 land. He'd enjoyed sending the message from the Oval Office to them up on the lunar surface. He kind of got the pageantry—he really understood the pageantry part. But he didn't get underneath the surface" (see "Nixon Remembers," p. 78).

Nixon's priorities reflected the drastic changes that had erased the optimism of the Kennedy years. In 1969 America was a nation torn by assassinations, riots, and dissent over Vietnam—a place vastly different from what it had been in 1961. As the problems of the cities and the threats to the environment began to draw growing concern, the public turned against big, expensive, high-tech projects in space. It could not have been a worse time to be a space visionary.

None of this daunted Paine; he still hoped that the Apollo 11 success would create a groundswell of support for the space program. Paine had one ardent supporter in Vice President Spiro Agnew, who was particularly enthusiastic about the manned Mars expedition, which he called an "Apollo of the 1970s." But Agnew was alone in his

support, and the Nixon administration's answer to Paine's plan was not long in coming: there would be no Apollo of the '70s, no manned Mars mission. Out of NASA's grand design for the future, only the space shuttle survived—and that just barely.

Implicit in these decisions was an appraisal of the true nature of the Apollo program. Apollo 8 astronaut William Anders, who served during this period as head of the National Aeronautics and Space Council, articulates it clearly: "The Apollo program was an anomaly. To expect to have a continuous string of anomalies—Apollo to Mars, Apollo to big space station, or Apollo to shuttle—is by itself a contradiction in terms. And basically, that's what NASA expected."

Nixon was fond enough of Apollo to save the bulk of the lunar landing missions from the budgetary ax, perhaps, as Paine and others have suggested, because he reaped the prestige of each Apollo triumph without having to spend much on space. In 1972 each Apollo mission cost NASA almost $500 million ($1.5 billion in current dollars). At NASA headquarters the feeling was that after six successful landings Apollo had reached the point of diminishing returns (a view that lunar scientists argued strongly against, to no avail). In 1970, forced to choose between Apollo hardware and funds and the Skylab and shuttle programs, Paine approved cancellation of the last three landings. Two decades later he stands by his decision. "If I had my life to live over," he says, Apollo 17 would still be "a perfectly reasonable place" to bring the program to a close.

Money, explain Paine and others, was not the only issue. Even after the success of Apollo 11, some at NASA felt that it was too dangerous to go back to the moon. Robert Gilruth, who headed the Houston space center during the Apollo years and who spoke of the astronauts as his "boys," argued repeatedly against further manned moon visits. "It's too risky," he used to say. "We're liable to lose one someday, and we can't afford that." Most of Gilruth's colleagues didn't share his reluctance, but they never forgot how much was at stake. The 1967 Apollo 1 fire had taught NASA that the public does not easily forgive accidents that kill astronauts. By late 1972 Christopher C. Kraft Jr., who had taken Gilruth's place, was telling Apollo 17 commander Eugene Cernan in the weeks before the mission, "Don't take any chances out there. We can't afford to lose one now." Kraft, like many of his colleagues, sensed that another Apollo fatality could have put the whole space program on the line. And when Cernan and his crew splashed down, Kraft and others were relieved that the whole risky business was over. By that time they had long known the end was coming, and, except for the scientists, everyone, including those who would've kept Apollo flying if the money had kept flowing, was now anxious to move on to the next projects: Skylab, the joint mission with the Soviets, and the space shuttle. Few mourned Apollo.

During the 1970s Apollo receded into a nostalgic past and thoughts of going back to the moon were lost in an uncertain future. NASA fared even worse with Gerald Ford and Jimmy Carter than it had with Richard Nixon, and by the time Ronald Reagan took office in 1981, NASA's mission was simply to stay alive. Serious thoughts of returning to the moon, along with most of the 1969 plan, fell dormant in NASA's file cabinets.

Things started to change shortly after the space shuttle began flying in 1981. At the Johnson Space Center in Houston two more elements of the 1969 plan were taking shape on engineers' drawing boards: a permanent manned space station and a fleet of Orbital Transfer Vehicles (OTVs) designed to shuttle between low Earth orbit and geosynchronous orbit, 22,000 miles up.

Meanwhile, NASA's unmanned explorations were facing virtual extinction from budget cuts. As part of an effort to salvage the unmanned program, Jeffrey Warner, a planetary scientist at the space center, was exploring an idea for a lunar observing satellite that could be dispatched to the moon from the shuttle's cargo bay. Like most planetary scientists, Warner rarely crossed paths with engineers involved in NASA's manned programs. When he did talk to them about his satellite he learned something startling. The engineers remarked matter-of-factly that once the space station and OTVs were in place—perhaps by the late 1990s—the nation could go to the moon any time it wanted. The reason: it takes slightly more energy to maneuver a spacecraft into geosynchronous orbit, still inside Earth's gravity "well," than to reach lunar orbit. Warner returned to his office and told this to his colleague, Wendell Mendell. At that time, Mendell says, a light bulb went off in his head. Suddenly the moon seemed very close.

Mendell became one of NASA's most active return-to-the-moon advocates. As a planetary scientist, he knew there were plenty of good scientific reasons to go back. Contrary to a widespread impression, the Apollo missions barely explored the moon and raised far more questions than they answered. Lunar scientists agree that only when a lunar base is established will they make sig-

PAUL DIMARE

nificant strides toward understanding how the moon formed and evolved.

Furthermore, the moon holds enormous potential for astronomy. It offers perfect conditions for observing deep space. Unlike a telescope in Earth orbit, which must be controlled by sophisticated computerized pointing systems as it whizzes around the globe, a telescope on the moon would require controls no more complex than those on earthbound instruments. Telescopes on the far side of the moon, completely shielded from terrestrial transmissions, would be free to study the most distant radio-emitting galaxies or search for extraterrestrial intelligence.

However, just as we did not go to the moon in the name of science to begin with, it's unlikely that science will be the reason for going back. Instead, talk has focused on the resources the moon has to offer. Oxygen, for example, is a constituent of some lunar minerals. Lunar oxygen would be valuable not only to settlers who harvested it, but also for spacecraft in Earth orbit that could use it for propellant—because of the moon's weaker gravity, shipping oxygen from the moon would be far cheaper than hauling it up from Earth.

Another lunar resource of potentially enormous value is helium-3, an isotope long known to physicists studying nuclear fusion as a cleaner, more efficient alternative to the fuels envisioned for "conventional" fusion reactors. On Earth, helium-3 exists only in minute quantities as a by-product of the production of thermonuclear weapons. But on the moon it is plentiful, one of the many gases deposited there by the sun in a stream of charged particles called the solar wind. Furthermore, according to University of Wisconsin nuclear physicist Jerry Kulcinski, if lunar settlers could harvest the gas they would reap other resources of great value for their own survival on the moon. For example, Kulcinski says, every ton of helium-3 extracted by lunar settlers would yield 3,300 tons of water. "If we had a helium-3 mine up there," he says, "we'd have enough water to have swimming pools."

Lunar resources aside, in the early 1980s Mendell's purpose, as he and colleague Michael Duke spearheaded a return-to-the-moon effort, was simply to convince NASA of one basic point: it will be easy for us to go back to the moon, so we should plan with the moon in mind. They encountered an agency whose sights had been lowered by long years of austerity. When he came to them with his ideas, Mendell recalls, NASA planners all but told him to go away.

The situation was an ironic reversal of that in 1969. For the first time since

Moon advocates believe that lunar settlements would prove a source of valuable raw materials. Helium-3, deposited on the moon by the solar wind, could become a remarkably cheap and efficient fuel for fusion reactors.

the Apollo days there was a space fan in the White House. Ronald Reagan "loved the space program," says James Beggs, who headed NASA through Reagan's first term. "It had all the things that he liked. It brought forth the best qualities of America."

Beggs remembers that when he went to the White House to ask for a space station—not von Braun's wheel but a modest, modular outpost in Earth orbit—Reagan not only greeted the proposal with enthusiasm, unlike most of his Cabinet, but stunned Beggs by asking, "Why don't we go all the way and go to Mars?" A surprised Beggs told Reagan that NASA had always considered the space station to be the next link in the chain leading out to the moon and Mars. In other words, the plan hadn't changed since 1969.

The plan had remained alive in the minds of NASA's leaders, but so much time had passed since the agency had gone public with long-range goals that it was thought to have none. By 1985 Congress became so fed up with the agency's year-to-year, piecemeal budget requests that it ordered the creation of the National Commission on Space to define long-term goals for the space program and present them to the president. In 1986, six months after NASA was devastated by the *Challenger* explosion, Thomas Paine, the commission's chairman, stood once more in the Oval Office and handed Reagan a leather-bound volume that was an updated version of the 1969 plan. With *Collier's* in mind, Paine had even included spectacular artwork to illustrate such recommendations as a lunar base and a manned mission to Mars. Accepting the report, Reagan said to Paine, "I know what you want me to say. You want me to say that we're going to carry out your recommendations. And I am happy to tell you that we are."

Reagan did not follow through on his pledge. He made no explicit public endorsement of anything beyond the space station (although Beggs says that when Reagan approved the station he was actually endorsing the essence of the 1969 plan). Reagan's aides did not share his interest and they let the initiative die. Perhaps it was because the economic and political climate of 1961 had completely changed by the 1980s. Or perhaps it was because Reagan already had launched his Apollo; it was called the Strategic Defense Initiative.

In the wake of the Paine commission's report, NASA created a space commission of its own, chaired by astronaut Sally Ride. The Ride report echoed many of the Paine commission's recommendations and sparked the creation of a NASA Office of Exploration. Today, for the first time since 1969, NASA is studying long-term plans for manned space exploration. A lunar base is one of four case studies the agency is preparing for presentation to the NASA administrator by 1992. As it studies techniques for creating a settlement on the moon, NASA is attracting strong interest from organizations that have nothing to do with space. The 100,000-member American Society of Civil Engineers, which recently sponsored a conference on extraterrestrial construction techniques, is among the most enthusiastic participants in lunar base studies.

It's precisely because the moon seems so accessible that many who seek a long-term goal for the space program reject it. Instead, a manned expedition to Mars is the most commonly suggested antidote to NASA's lack of direction. Mars is today what the moon was in 1961: just beyond reach, mysterious, awaiting the footsteps of human beings. But while many see the moon as the ideal proving ground for a Mars expedition, one Mars advocate, Apollo 11 astronaut Michael Collins, disagrees. "I think that you could do all the preliminaries in Antarctica, or in Earth orbit, or in Reno, Nevada, or some other place than the moon. I think the moon is just a detour that will siphon off a great deal of money and energy, and it's not a place that will really excite the American people. They've already been there."

Even if Collins is right, the moon has lost none of its allure abroad. Other countries, even some whose space programs are still in their infancy, include the moon in their plans. Mendell says, "You know where the most civil engineers studying the moon are? They're in the Shimizu Corporation and Ohbayashi Corporation in Japan. They're the ones doing the lunar base studies." They are puzzled, Mendell says, when the Americans talk of sprinting to Mars and bypassing their nearest neighbor. The Japanese see the same logic that Wernher von Braun did: the moon has an unalterable place in human expansion away from Earth. Again and again those who have formulated a plan for human activities in space—Paine's NASA in the '60s, Mendell and the moon advocates, the National Commission on Space, the Ride commission—have reconstructed that logic from scratch. As Paine says, "That's just the way the solar system is constructed."

PAUL DIMARE

To most observers in this post-*Challenger* era, whether the moon or Mars is the United States' target in space isn't the issue. As astronaut William Anders says, "I don't really care where they go, just as long as they go someplace." That is exactly the point. Whether we go back to the moon is really part of a much larger question:

Destination Mars? Some question whether a visit to the moon should be part of such a mission.

Will the country fulfill what some say was Kennedy's broader goal and commit itself once again to being a spacefaring nation? This is a policy question that NASA can't answer. For the space agency, the exciting prospects of reaching out into the solar system once more have to be balanced against more pressing issues, such as the great disarray of the space station project, questions about the shuttle fleet's ability to carry the agency through the 1990s, and how to keep selling space to a society that has not yet accepted the necessity of a civilian space program.

But one of the lessons of Apollo is that the decision to "go someplace" can't come from anyone in NASA, or from the moon advocates, or from the Mars advocates. It's got to come from the top.

Some say that since Apollo the fire has gone out of NASA, that it has become too encumbered by its own bureaucracy to promote a vigorous space program. Others look to the White House, wondering when the kind of vision that launched Apollo will return. And there are those who say, simply, that it is impossible to find another goal in space as clear and compelling as the moon. Whatever the reason, it is hard to escape the feeling that something we gained on that hot July night in 1969 is gone now. At the space centers, the handful of leftover Saturn Vs lie on exhibit stands like grand sailing ships, reminders of a unique and spectacular period in human history. It is that sense of focus that now seems as distant as the moon itself. Today we search for direction. Twenty years ago we reached for the moon, and made it.

APOLLO LOG

The 12 Americans who have walked on the moon are:
Neil Armstrong (civilian), Wapakoneta, Ohio
Edwin Aldrin Jr. (USAF), Montclair, New Jersey
Charles "Pete" Conrad (USN), Philadelphia, Pennsylvania
Alan Bean (USN), Fort Worth, Texas
Alan Shepard (USN), East Derry, New Hampshire
Edgar Mitchell (USN), Artesia, New Mexico
David Scott (USAF), San Antonio, Texas
James Irwin (USAF), Pittsburgh, Pennsylvania
John Young (USN), San Francisco, California
Charles Duke (USAF), Charlotte, North Carolina
Harrison Schmitt (civilian), Santa Rita, New Mexico
Eugene Cernan (USN), Chicago, Illinois

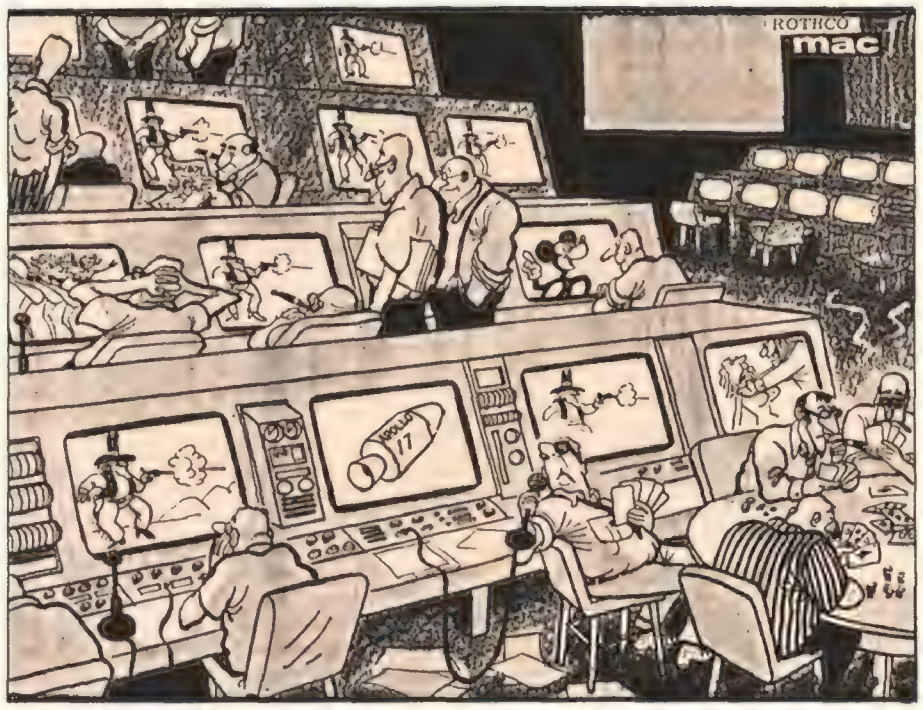
The six men who orbited the moon while their crew members landed are:
Michael Collins (USAF), born in Rome, Italy
Richard Gordon (USN), Seattle, Washington
Stuart Roosa (USAF), Durango, Colorado
Alfred Worden (USAF), Jackson, Michigan
Thomas Mattingly (USN), Chicago, Illinois
Ronald Evans (USN), St. Francis, Kansas

Where are they now?

Following the Apollo 11 mission, mission commander Neil Armstrong served at NASA headquarters in Washington, D.C., as deputy associate administrator for aeronautics. He resigned from NASA in August 1971 to become a professor of engineering at the University of Cincinnati. In 1979 he joined the Cardwell International Corporation in Lebanon, Ohio. He now serves as chairman of CTA, Inc., a computing systems company in his home state of Ohio.

Lunar module pilot Edwin Aldrin Jr., who had his first name legally changed to "Buzz" in the late 1970s, resigned from NASA in July 1971 to return to the Air Force as commander of the Test Pilot School at Edwards Air Force Base, California, becoming the first astronaut to return to military service. In 1972 he retired from the Air Force and founded Research & Engineering Consultants. Since 1985 he has been a professor at the Center for Science at the University of North Dakota in Grand Forks.

Command module pilot Michael Collins resigned from NASA in January 1970 to become assistant secretary of state for public affairs. From 1971 to 1980 he worked for the Smithsonian Institution as director of the National Air and Space Museum and then as under-secretary for the Institution. Over the next four years he was vice president of the Vought Corporation in Arlington, Virginia. He is now president of Michael Collins Associates in Washington, D.C.



"Eh? Who? Oh, yeah, sure boys—tremendous excitement down here—the whole world's agog!"

The 12 moonwalkers spent a total of 300 hours on the moon and brought back 842 pounds of rocks and soil. Today nearly 80 percent of the materials are stored in the Lunar Sample Building at Houston's Johnson Space Center. Five percent are on loan to scientific institutions, schools, and museums; three percent have been destroyed by testing. The remainder is stored at Brooks Air Force Base in San Antonio.

"It's the latest traveling outfit . . . you'll be a sensation."

HISTORICAL BEGINNINGS

Signature Collection of American and Soviet Pioneers

Size: (25" x 35") 1" Border

Artist: George Bishop

MERCURY 7

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On May 5, 1961, America launched the historic beginnings of her space program. Our famous Mercury astronauts have come together since those historic beginnings to commemorate for the first and only time the Mercury program with this historically significant limited edition offering. The very visual and breathtaking "Mercury 7" offset lithograph was commissioned and each historic art print hand signed by "The Right Stuff" astronauts, Senator John Glenn, Alan Shepard, Walter "Wally" Schirra, Gordon "Gordo" Cooper, Donald "Deke" Slayton, Betty Grissom (for Gus), and Scott Carpenter.

- **Limited Editions of 1500**
- **Each Hand Signed**
- **Certificate Of Authenticity**
- **Historic First Ever Offering**

APOLLO-SOYUZ

IT BEGAN WITH A HANDSHAKE

On July 17, 1975, a most historic handshake took place that changed the course of history. It can truly be said that in 1975, high above the earth, the seeds of openness, of Glasnost, were planted and are blossoming today. We have recaptured for the first and only time this historic handshake with the issuance of this once only limited edition. The specially commissioned and dramatic "Apollo-Soyuz" offset lithographs are each hand signed by the two famous Soviet cosmonauts who flew the mission, Alexi Leonov (first man to walk in space) and Valeri Kubasov, and for the Americans, mission commander Thomas Stafford and Donald "Deke" Slayton.

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Artist: George Bishop

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The Judgment of Time on Space

John Logsdon
Director,
Space Policy Institute,
George Washington
University

We asked the world to accept space achievements as a measure of a nation's character.

For twenty years an astronaut standing by an American flag planted on the moon has been one of the most pervasive symbols in the world. It has almost always been a positive one. Project Apollo accomplished in 1969 the purposes envisioned by President Kennedy eight years earlier. It offered undeniable proof of American technological and industrial vitality, and it told Americans that they could achieve great things. But the arrival of human beings on another celestial body was so powerful an accomplishment that it has taken on many meanings that the original Apollo backers could not have foreseen. Twenty years later the question of what was gained from Apollo is still open.

The gain for science was modest, at least in some opinions. Physicist Freeman Dyson has commented that Apollo "yielded a harvest of solid scientific information . . . . All was good science, but it was not great science. For science to be great it must involve surprises, it must bring discoveries of things nobody had expected or imagined." This is a tough measure of greatness. Analyses of Apollo's returned cargo have not resulted in any Nobel prizes, but that does not diminish the contribution these materials have made to our knowledge of the moon and the solar system.

The six Apollo missions that landed on the moon brought back more than 2,000 samples of lunar material weighing a total of 842 pounds. (By contrast, three automated Soviet missions in 1970, 1972, and 1976 brought back samples weighing a total of 11.3 ounces.) Instruments placed on the lunar surface by Apollo astronauts detected moonquakes and impacts from meteorites and recorded the heat flowing out from inside the moon. The chemical composition of one quarter of the moon's surface was determined by cameras and radioactivity detectors on Apollo craft.

From Apollo's scientific harvest, we now know that Earth and the moon were formed at the same time, some 4.6 billion years ago, and that they are made of the same chemical elements, though in very different proportions. We know that the moon has never supported life. Its early history was violent, with its outer surface being initially molten, then bombarded by huge meteorites that created vast basins. Those basins were then filled by floods of lava from inside the moon, creating the dark "seas" visible from Earth. Perhaps as many as three billion years ago, volcanic activity ceased, and since that time the lunar surface has remained essentially unchanged except by impact from an occasional meteorite and bombardment from solar and cosmic radiation. This stability means that much of the history of the solar system during those three billion years can be read from lunar rocks. We may also find clues to an even earlier time. Although the oldest known rock on Earth is 3.8 billion years old, some fragments from the moon may date back to the very creation of the solar system.

The scientific legacy of Apollo, however, can be considered a bonus, and criticisms that the project was a distortion of scientific priorities are somewhat beside the point. When President Kennedy began the lunar landing project, his science advisor, Jerome Wiesner, told him that the undertaking could not be justified on scientific grounds. Kennedy assured Wiesner that the other reasons for going ahead with Apollo were sufficiently compelling.

In 1961, Kennedy, as well as many others, believed that visible achievement in space would become an essential element of national power and international leadership. As a symbolic undertaking driven by these political objectives, Apollo delivered. Within months of Kennedy's clarion call, NASA and U.S. industries and universities were galvanized in a high-profile mission to make a lunar landing. This mobilization, with its promise of

Apollo won the race. Twenty years later, we're still assessing our winnings.

prestigious and challenging careers, stimulated many young men and women to excel in technical studies. The United States gained immense engineering and operational experience and made significant capital investments in facilities for space exploration. And at the end of a long, divisive decade, many Americans saw in Apollo a reason for pride in common achievement. Today, almost every American who was old enough remembers where he or she was when Neil Armstrong took the giant leap.

The U.S. space program became a source not only of national pride but of international respect. By the mid-1960s, the successive achievements of projects Mercury and Gemini, seen as part of the lunar quest, had effectively countered the psychological and political advantages that the Soviet Union had gained from orbiting the first satellite and the first human being. U.S. diplomats and other Americans who were abroad at the time of the moon landings attested to the immense admiration expressed for the country that had accomplished such a feat.

Over time, the pride and admiration have been tempered by other reactions, particularly in this country. The Apollo achievement has become a benchmark against which to measure the inability of American society to mobilize its resources to address other goals. We look back 20 years with nostalgia for past successes, and wonder why a country that once could send men to the moon cannot now use its skills and wealth to solve Earthbound problems. We asked others in the world to accept space achievements as a measure of a nation's character; then, in the aftermath of Apollo, we backed away from our own commitment to space.

Space advocates failed in 1969 to convince Richard Nixon and his aides that the capabilities developed by Apollo were essential to the country or even politically beneficial for his term. Proposals for a continuing, expensive program of solar system exploration were overshadowed by the issues of pollution, poverty, economic competitiveness, and détente.

NASA itself actually suffered from its success. Apollo shaped it into an organization driven to develop large-scale technology for dramatic goals, yet the moon landings seemingly "used up" destination as a rationale for ambitious space efforts. In effect, the United States started over in space with the flawed 1972 decision to develop a reusable space transportation system. And NASA, unable to adjust to its lower priority in the overall scheme of national affairs, became a stagnant bureaucracy with a fortress mentality, unwilling to share information or admit problems for fear of incursions into its mandate as the country's premier space organization.

This is the balance sheet for Apollo after only 20 years. It is certain that future people of Earth will have other reactions to the astronaut who stands next to the flag on the moon. Like other initial ventures into unknown territory, Apollo may not have followed the best route, nor have been motivated by the same concerns that will drive those who follow. But without someone having been first, there can be no followers.

Apollo 11 astronaut Michael Collins has frequently said that the space program—and Apollo most of all—is about leaving. There is little question that humans will again leave their home planet for voyages of exploration to the moon, Mars, and beyond. When that happens, the brief period of lunar exploration that began on July 20, 1969, will certainly be seen as the trailblazing expedition in the movement of humanity outward from its home. That will be the ultimate legacy of Project Apollo, however one assesses its 20th century meaning and value.

In the aftermath of Apollo, we backed away from our commitment.

Flying With Howard

In 1939 Transcontinental and Western Air—TWA—asked the Lockheed Corporation to design an airliner that would carry 100 passengers and 6,000 pounds of cargo across the United States or the Atlantic Ocean at 20,000 feet and 350 mph. The result was the Constellation, Lockheed's first large transport.

Kelly Johnson, head of Lockheed's famous Skunkworks, was a key player in the development of the graceful four-engine Constellation. In his autobiography, Kelly—More Than My Share of It All, *Johnson devotes a chapter ("The Big Time") to the challenges Lockheed faced in building an airliner with such advanced systems as hydraulically boosted controls, a pressurized cabin, and reversible propellers.*

But Johnson's biggest headaches were caused by TWA's principal stockholder, Howard Hughes, who had his own ideas about how to publicize the airliner and his supposed contributions to it.

The Constellation made its first flight on January 9, 1943, in military olive drab paint, as the C-69. We had delayed the flight for two days because of very high winds—too high for a first flight with a large, new transport. The press corps—radio and newspaper reporters, press photographers, magazine writers, newsreel cameramen—would appear each morning only to be invited twice to adjourn to the air terminal Skyroom for breakfast and a wait while we hoped for the winds to subside, finally gave up and cancelled the flight. We were all happy when the third day dawned more gently.

The airplane made six successful test flights that day. Its accelerated service tests for the military at Wright Air Development Center, Ohio, set a record—170 flying hours completed in 30 days. The airplane also had the distinction of carrying in the cockpit Orville Wright on what would be his last flight.

At the end of World War II, Lockheed was in the enviable position of having a new, highly-advanced transport, thoroughly tested in military service and ready for commercial airline production. The first deliveries of an initial Model 049 actually were conversions of Air Force C-69s already in work. It took only 90 days to turn out the first commercial model, which went to TWA in November 1945.

There were big plans to publicize introduction of this new transport in service with TWA. Howard Hughes himself wanted to be at the controls of what would be a record-breaking, cross-country flight carrying press and Hollywood celebrities. He earlier had established a reputation as a pilot. In fact, he was awarded the Collier Trophy for an around-the-world record flight in 1938. He flew his Model 14 at an average speed of 206 miles an hour over a 15,000-mile route in 3 days, 19 hours, and 9 minutes. We had not worked with him on that venture, although it was with a Lockheed airplane. He had the extra fuel tanks installed on his own.

Hughes would have to be checked out in the new airplane before attempting the cross-country flight, of course. So, before it was delivered to TWA, Milo Burcham, Dick Stanton as flight engineer, and I took Hughes and [TWA president] Jack Frye on a demonstration and indoctrination flight. Frye was just observing, but Hughes was to learn how the plane performed and how best to handle it.

Our normal procedure in checking out a new pilot in an airplane was to go through the maneuvers carefully, then have the student follow through on the controls from the copilot seat.

We had just taken off from Burbank and were only a few thousand feet over the foothills behind the plant when Hughes said to Milo: "Why don't you show me how this thing stalls?"

So Milo lowered the flaps and gear, put on a moderate amount of power, pulled the airplane up, and stalled it. The Constellation had fine stall characteristics, not falling off, and recovering in genteel fashion.

Hughes turned to Milo and said, "Hell, that's no way to stall. Let me do it."

Milo turned the controls over to him. I was standing between them in the cockpit. Howard reached up, grabbed all four throttles and applied takeoff power with the flaps full down. The airplane was so lightly loaded it would practically fly on the slip stream alone. Hughes then proceeded to pull back the control all the way, as far as it would go, to stall the airplane.

Never before nor since have I seen an airspeed indicator read zero in the air. But that's the speed we reached—zero—with a big, four-engine airplane pointed 90 degrees to the horizon and almost no airflow over any of the surfaces except what the propellers were providing. Then the airplane fell forward enough to give us some momentum. Just inertia did it, not any aerodynamic control.

At that point, I was floating against the ceiling, yelling, "Up flaps! Up flaps!" I was afraid that we'd break the flaps, since we'd got into a very steep angle when we pitched down. Or that we'd break the tail off with very high flap loads.

Milo jerked the flaps up and got the airplane under control again with about 2,000 feet between us and the hills.

I was very much concerned with Howard's idea of how to stall a big transport.

We continued on our flight to Palmdale Airport, where we were going to practice takeoffs and landings. That whole desert area was mostly open country in those days and an ideal place for test flying.

Once on the runway, Milo and Howard exchanged seats. On takeoff from Burbank, Milo had shown Howard what the critical speeds were; so Howard now took the plane off. But he had great difficulty in keeping it on a straight course. He used so much thrust and developed so much torque that the plane kept angling closer and closer to the control tower. We circled the field without incident and came in for an acceptable landing. Then Howard decided to make additional flights, and on the next takeoff he came even closer to the control tower, with an even greater angle of yaw. He was not correcting adequately with the rudder. He made several more takeoffs and landings, each worse than the last. He was not getting any better at all, only worse. I

SUMMA CORP. COURTESY OF QUEEN MARY HISTORICAL ARCHIVES (2)

Government officials inspected the Constellation but fortunately didn't have to fly it with Hughes (fourth from right).

was not only concerned for the safety of all aboard, but for the preservation of the airplane. It still belonged to us.

Jack Frye was sitting in the first row of passenger seats, and I went back to talk to him.

"Jack, this is getting damned dangerous," I said. "What should I do?"

"Do what you think is right, Kelly," he said. That was no great help; he didn't want to be the one to cross Hughes.

I returned to the cockpit. What I thought was the right thing to do was to stop this. And on the sixth takeoff, which was atrocious, the most dangerous of them all, I waited until we were clear of the tower and at pattern altitude, before I said: "Milo, take this thing home."

Hughes turned and looked at me as though I had stabbed him, then glanced at Milo.

I repeated, "Milo, take this thing home." There was no question about who was running the airplane program. Milo got in the pilot's seat, I took the copilot's seat, and we flew home. Hughes was livid with rage. I had given him the ultimate insult for a pilot, indicating essentially that he couldn't fly competently.

A small group was waiting for us at the factory to hear Hughes's glowing report on his first flight as pilot of the Constellation. That's not what they heard.

Robert Gross [Lockheed board chairman] was furious with me. What did I mean, insulting our first—and best—customer? It was damned poor judgment, he said. [Engineer Hall] Hibbard didn't tell me so forcefully that I'd made a mistake, because he always considered another person's feelings, but he definitely was unhappy and let me know it. Perhaps most angry of all was the company's publicity manager, Bert Holloway. He had a press flight scheduled that would result in national attention, headlines in newspapers across the country and in the aviation press around the world. Because, of course, the plane would set a speed record. Would Hughes follow through

Legend had it that Hughes designed the Constellation; in reality, he merely scribbled some specifications.

as planned? By that time, I didn't care what anyone else said. I went home and poured some White Horse and soda.

It was a frigid reception I received next day at the plant. But when I explained what the situation had been, that in my judgment I did the only thing I could to keep Hughes from crashing the plane, and then Hughes later agreed to spend a couple of days learning how to fly the plane as our pilot would demonstrate, the atmosphere thawed.

We offered a bonus to our flight crew to check Hughes out in the plane over the next weekend. Rudy Thoren, our chief flight test engineer, took my place. I never flew with Hughes again; it was mutually agreeable.

* * *

On his next time in the airplane, Hughes changed his attitude considerably. He followed instructions carefully. He was the only pilot I ever knew, though, who could land one of our airplanes at cruising speed! He must have made 50 or 60 practice takeoffs and landings over that weekend. In fact, he was flying right up to takeoff time for the cross-country flight.

On the flight, as he was approaching Denver, Hughes encountered a big thunderstorm that had not been predicted. Instead of flying around or over it, and perhaps adding to the flight time, he plowed right through it. Unfortunately, the passengers had not been warned of turbulence and several not strapped in their seats were injured, though not seriously.

A record transcontinental crossing was set—Los Angeles to Washington, D.C., in an elapsed time of 6 hours, 57 minutes, 51 seconds.

From then on, the "Connie," as the plane

soon came to be called, established records every time it first flew from point to point.

* * *

There was a myth circulating for some years that Howard Hughes had designed the Lockheed Constellation. It was not discouraged by Howard, and certainly was not true. His specifications had consisted of half a page of notes on the size, range, and carrying capacity he wanted. It was not without some encouragement from us—I did not appreciate someone else's taking credit for our work—that eventually both Hughes and Frye acknowledged the misconception in November of 1941. They offered to publish advertisements, but Robert Gross was satisfied that their letter stated: " . . . to correct an impression . . . prevalent in the aircraft industry . . . the Constellation . . . airplane was designed, engineered and built by Lockheed."

Hughes used to keep at least one Constellation parked on our flight line—he had one of just about every type of plane stashed away somewhere; and he would phone his favorite flight test engineer at Lockheed, Jack Real ([later] head of Hughes Helicopters), in the early morning hours about once a month, wanting to come over, climb into the cockpit, run up the engines, and just sit there awhile. Real would join him.

The personal eccentricities that later were to become obsessions and make a tragedy of Hughes' life had not yet manifested themselves—at least, not to us. Hughes and Real became good friends.

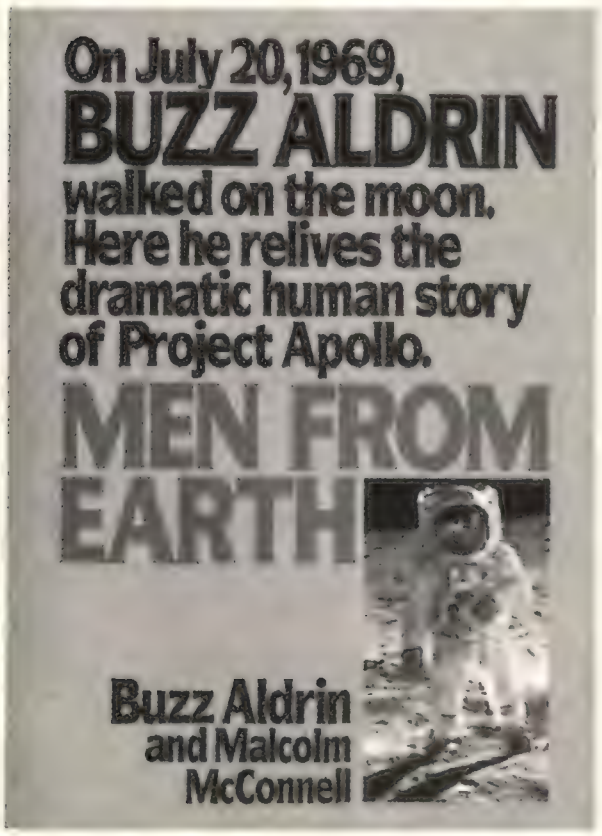
While Hughes and I never again flew together, I heard from him directly during the period when he was developing his wooden Flying Boat, now a tourist attraction alongside the *Queen Mary* at Long Beach harbor in California.

Men From Earth *by Buzz Aldrin and Malcolm McConnell. Bantam Books, 1989. 336 pp., b&w photos, $21.95 (hardbound).*

Footprints: The 12 Men Who Walked on the Moon Reflect on Their Flights, Their Lives, and the Future *by Douglas MacKinnon and Joseph Baldanza. Acropolis Books Ltd., 1989. 375 pp., color and b&w illustrations, $19.95 (hardbound).*

Anniversaries occurring in 10- and 50-year intervals customarily call for special commemoration. Hence the debut of these two books, evidently inspired by the same stimulus: the 20th anniversary of man's first landing on the moon.

Of the two, *Footprints* is the less successful. No false advertising here: what the subtitle promises is what you get—except that "reflect" suggests a more thoughtful examination than I found in most of these discussions. The 12 interviews, each preceded by a good biographical sketch of the astronaut, are mostly unstructured and minimally directed. Some are short, some long (Ed Mitchell gets nearly four times as much space as Neil Armstrong)—probably depending on how much time the subject could spare and how willing he was to talk. The authors ("compilers" seems a better word) make no attempt to tie the segments into a coherent whole. The astronauts, for the most part, offer no penetrating insights that they have not revealed elsewhere; I sensed in some interviews that they had covered this ground many times before and may be growing weary of it.

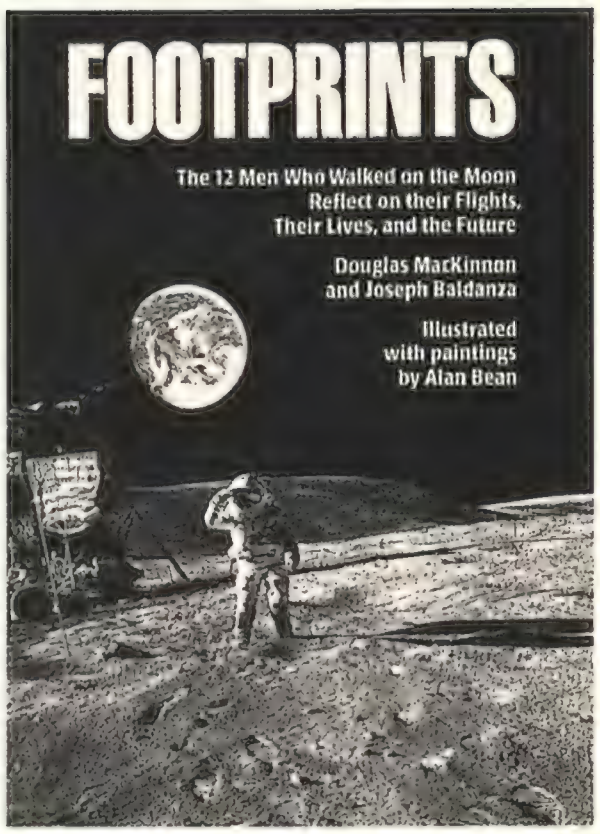


Footprints is a nice try, but does not quite offer what its authors must have hoped for. The lode of astronaut impressions was never as rich as might have been expected and has been pretty well mined, if this sampling is representative. The book's shortcomings are partially offset by its illustrations: reproductions of some of astronaut-artist Alan Bean's paintings.

Men From Earth accomplishes more. Malcolm McConnell is a journalist who has covered space programs for many years, and Buzz Aldrin was lunar module pilot for Apollo 11 and an astronaut for eight years. They have constructed a workman-like history of manned spaceflight interwoven with Aldrin's experiences in the Gemini and Apollo programs.

Theirs is the first popular book I have seen that treats the American and Soviet manned programs chronologically and in parallel, shifting the viewpoint of the narrative from the U.S. to the U.S.S.R. as major advances are made on each side. Drawing on the work of American observers of the Soviet program and on interviews with U.S. intelligence officers who were in a position to know, Aldrin and McConnell make a convincing case that the moon race lasted longer than most Americans realized and Soviet officials would admit. The race ended with the spectacular explosion of a fully fueled G-1 booster set to launch the first full-scale Earth-orbiting test of the Soviets' lunar landing system (see "The Other Side of the Race," p. 36). Two weeks later, Apollo 11 was launched.

The book is well researched and the writing is competent, but the mixture of



omniscient and first-person points of view—the latter appearing when Aldrin's personal experiences enter the story—is a little hard to get used to. Much of Aldrin's contribution is a reiteration of experiences he detailed earlier in *Return to Earth* (Random House, 1973). At the end, however, he covers new territory with a forceful assessment of the post-Apollo U.S. program, plus an ingenious plan for the systematic long-term manned exploration of Mars.

—Wm. David Compton is the author of Where No Man Has Gone Before, *a history of the Apollo lunar exploration missions to be published by NASA later this year.*

Cabin Pressure *by Corylee Spiro and Elizabeth Harwell. St. Martin's Press, 1989. 256 pp., line drawings, $16.95 (hardbound).*

Isn't it funny the way Asians say "westwoom" instead of "restroom"? And how about the Saudi Arabian who thought the toilet was a bathtub and washed up with

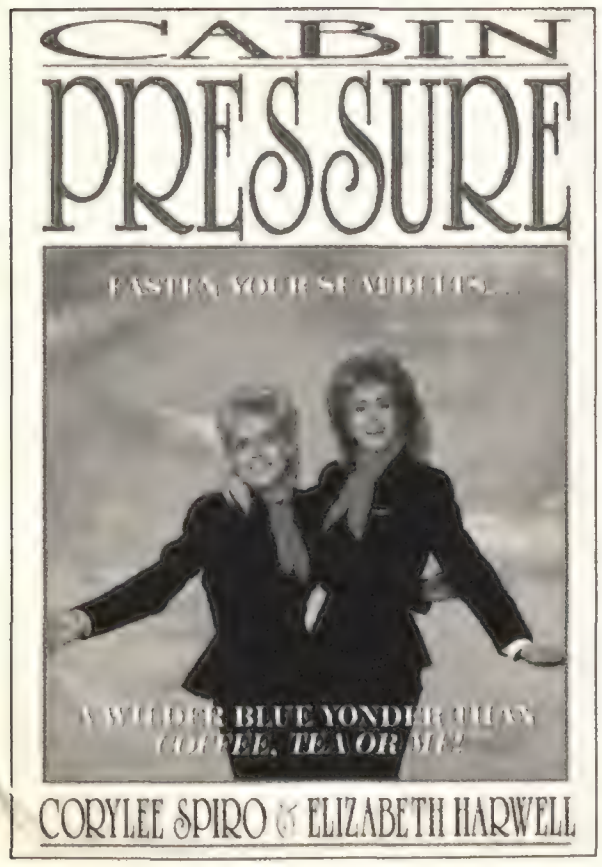
its water—wasn't he stupid?

The answer to these questions is: of course not. That is, unless you are Corylee Spiro and Elizabeth Harwell, the two flight attendants who co-authored *Cabin Pressure.* Just when the battle against stereotyping people seems to be gaining ground, it is especially dismaying to encounter a book in which the common stereotypes are perpetuated and some new ones are added.

In a series of humorless anecdotes, Spiro and Harwell make fun of Parisians (rude, of course), homosexuals ("fairy tales"), baggage handlers (hairy and horny), and passengers and co-workers (jokes about their low IQs abound). The anecdotes all end with cheerful clichés: "All in a day's work" or "Frogs and snails and puppy dog tails!" or "Ouch."

What the book lacks most is balance. Despite assurances that they love people and their jobs, I saw no evidence of this. It's all right to show the negative side of the job, but there are no beautiful moments shared here, no truly touching stories. The authors' idea of something sensitive is a tale about mistaking a seeing passenger for a blind one. This is not really surprising, considering their idea of fun is catching someone picking his nose or with her pants down—literally.

There is a thin thread throughout the book that refers to deregulation and all the problems it's caused. But deregulation can hardly be blamed for sexism, racism, and bigotry. The authors of *Cabin Pressure* think it's cute when men refer to women as "dear" and funny when the Miami-JFK run is called "the Bagel Bullet" or "Kosher



Komet." Saddest of all is that these women are in a job that affords them the opportunity to experience a variety of people and cultures, yet any person or thing alien to them is laughed at.

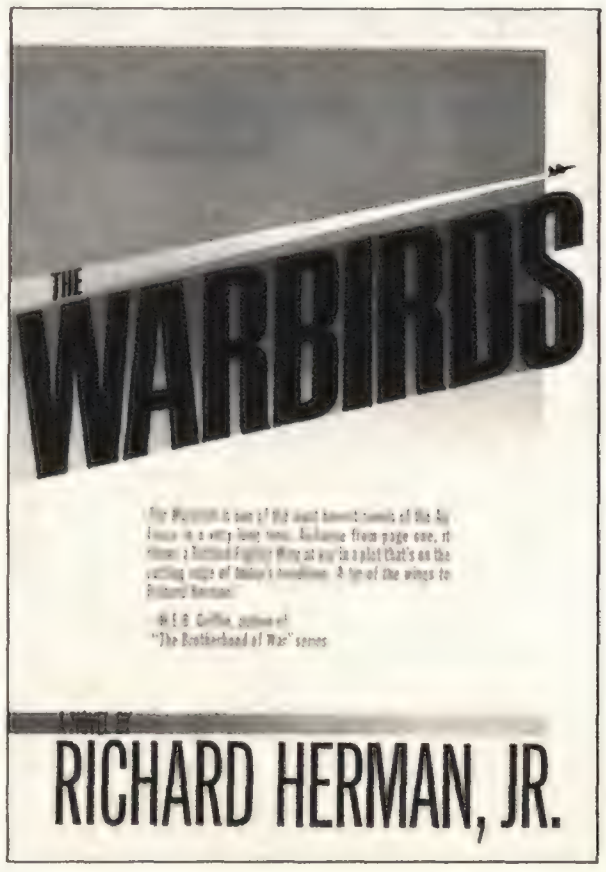
I suppose if a group of plumbers or accountants got together, they would share stories they thought were funny. That doesn't mean those stories should be published. The same is true of *Cabin Pressure,* an exercise in poor taste that should have stayed in the authors' apartment, where it was conceived. In their own words, "Ouch."

—Ann Hood, a former flight attendant, is the author of the novels Somewhere off the Coast of Maine *and* Waiting to Vanish.

***The Warbirds** by Richard Herman, Jr. Donald I. Fine, Inc., 1989. 383 pp., $18.95 (hardbound).*

As a genre, the techno-thriller may be defined as a novel in which hardware assumes a role at least as important as that of the human characters. But although Richard Herman, Jr.'s *The Warbirds* deals with military aviation, his novel is more about people than equipment.

The book is wrapped around the fictional 45th Tactical Fighter Wing, an F-4 Phantom unit based in Egypt. When one of the wing's aircrews downs a Libyan MiG that's attacking an American C-130 on an international relief mission, the ship hits the sand, so to speak. A postmortem reveals that the MiG pilot was Russian, prompting the 45th's withdrawal from the region.



After regrouping and retraining in Great Britain, the wing is sent to Saudi Arabia to support a small, ineffective Arab peacekeeping force acting as a buffer between Iran and Iraq. Supported by only an F-15 squadron, the 45th wages a lone battle against the heirs of the Ayatollah, who have allied themselves with the Soviets.

Herman stalls and spins on two main points. It seems highly unlikely that the death of a single Soviet pilot would have such repercussions—and even more unlikely that the U.S. Navy carrier battle group in the North Arabian Sea would not become involved, as it does not have to rely upon wavering allies for basing rights.

The author noses over and recovers nicely, however; his characterizations of Air Force life, in peacetime and in combat, are well drawn. From the hard-nosed chief of staff to the NCOs who really run the service, Herman's characters are believable people with both strengths and failings. There are insufferable pilots and sympathetic ground-pounders (and vice versa); there are warriors and there are managers. The women are not merely love interests but competent professionals, some of whom are killed in the line of duty.

The climax is taut and believable. Faced with increasing attrition, the 45th begins evacuating its untenable base, flying until the last possible moment. The ending is not an entirely happy one, but the plot is all the more credible for it.

Herman shines when he describes combat tactics, and, with 500 hours in F-4s, he obviously knows the Phantom intimately. But it's his characters that carry the story, which is as it should be. After all, an air force *is* people more than airplanes. Always has been, always will be.

—Barrett Tillman is author of seven volumes of aviation history. His first novel will be published by Bantam next year.

***Target Stealth** by Jack Merek. Warner Books, 1989. 399 pp., $18.75 (hardbound).*

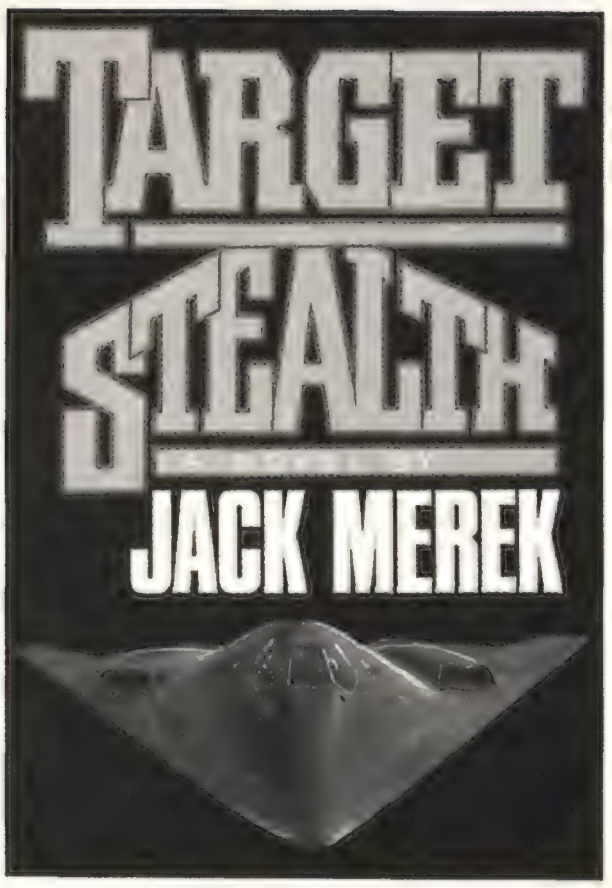
Target Stealth has all the right ingredients for a first-rate techno-thriller. High-tech weaponry, hard-bitten test pilots, fanatical Iranian terrorists, Soviet moles, CIA renegades—even a kinky KGB seductress in leather—fill the pages of this potboiler. But while author Jack Merek scores high marks for adventure and espionage, he falls short in describing the technological wizardry of the aerospace world.

The story begins in Beirut when a KGB courier en route to Moscow with stolen plans for America's super-secret B-2 Stealth bomber falls into the hands of

Iranian agents. Colonel Asrar Ajami Avadek, a ruthless Iranian intelligence officer who learned his trade from the CIA before the Shah's downfall, concocts a daring plan to hijack the bomber. He enlists the aid of a handful of U.S.-trained Iranian pilots who have honed their skills in years of aerial combat with Iraqi fighters.

Two crack U.S. Air Force test pilots stand between Avadek and his goal. General Scott Cartwright, a former hotshot fighter pilot and astronaut, is called out of retirement to plug the security leak. The hard-charging Cartwright takes on pestering reporters, egotistical defense contractors, and anyone else with the temerity to get in his way. His partner is Major Adam Glassman, a brilliant flier who lost his nerve after he saw his brother die in a fiery crash during a test flight. Scarred by his experience as a prisoner of war during the U.S. incursion in Lebanon, Glassman has a score to settle with Avadek.

While the novel is short on character development, Merek keeps the pace fast and the dialogue tight. He does a good job describing the world of test pilots and the secret skunkworks where America's latest



aerospace technology is developed and put to the test. The book is sprinkled with technical details, although far less so than other books of this genre. Here Merek is on shakier ground. Some glaring slip-ups and improbable occurrences detract from the story. Radar locks onto targets *after* missiles are fired rather than before, and Air Force airplanes are loaded with incompatible Navy Phoenix missiles.

In a particularly improbable plot twist, a prototype of the Air Force's advanced tactical fighter just happens to land at the Stealth bomber plant minutes before the Iranian hijackers spring into action, providing Cartwright and Glassman the means to give chase. And although it is a prototype, it is conveniently loaded with no fewer than four different types of missiles, plus a Vulcan cannon. It may sound like an Air Force pilot's dream, but it's far from realistic.

The technical detail in Merek's novel lacks the comprehensibility that made Tom Clancy's *The Hunt for Red October* such a hit. Still, if you can overlook these faults, *Target Stealth* is a good, fun read.

—John Morrocco, author of two books on the air war in Vietnam, is military editor for Aviation Week & Space Technology.

Credits

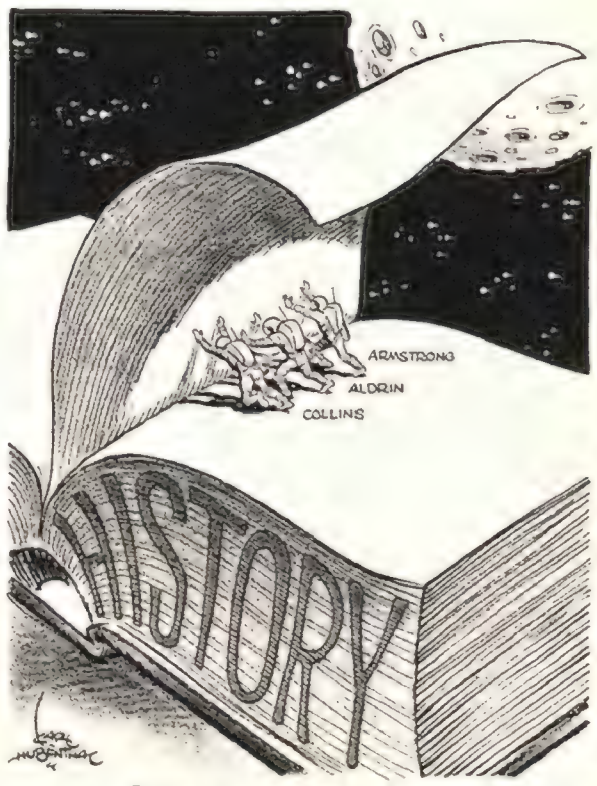
Snapshot. Air Vice Marshal Ron Dick is an International Fellow at the National Air and Space Museum. His last story for *Air & Space/Smithsonian* was "The Schneider Trophy" (June/July 1988).

Measuring Up. Jake Page's last article, "Three If by Air . . . ," appeared in the August/September 1987 issue of *Air & Space/Smithsonian.*

A Great New Enterprise. Wayne Biddle, a Washington, D.C.-based journalist, is writing a history of the aerospace weapons industry.

The Other Side of the Race. Phillip S. Clark works for Commercial Space Technologies in London. He is an expert on the Soviet and Chinese space programs and the author of *The Soviet Manned Space Program* (Orion, 1988).

A Smooth Spot in Tranquility. Don Wilhelms worked at the U.S. Geological Survey for 24 years, mapping the moon during the Ranger, Surveyor, Lunar Orbiter, and Apollo programs.



KARL HUBENTHAL CARTOON, *LOS ANGELES HERALD-EXAMINER*

Start a whole new chapter

Requiem for a Heavyweight. Science writer T.A. Heppenheimer is a frequent contributor to *Air & Space/Smithsonian.*

A Trip to the Moon. The science editor of *National Geographic* for many years, Kenneth F. Weaver covered the space program from Mercury through Apollo.

Meanwhile, Back on Earth. Charlotte Evans, a *New York Times* reporter and editor for 12 years, is looking for a wealthy husband so she can continue freelancing.

Why Haven't We Gone Back? Andrew Chaikin is a science writer who specializes in space exploration. His story of the Apollo astronauts and their experiences is forthcoming from Viking Press. He wishes to thank John Logsdon, whose unpublished manuscript aided the research of this article.

Further reading on Apollo:

Apollo Expeditions to the Moon, edited by Edgar M. Cortright, NASA, 1975.

Chariots for Apollo: A History of Manned Lunar Spacecraft, C. Brooks, J. Grimwood, L. Swenson, NASA, 1979.

Fundamentals of Rockets, Missiles, and Spacecraft, M. Hobbs, John F. Rider, 1964.

Liftoff: The Story of America's Adventure in Space, M. Collins, Grove, 1988.

Men From Earth, Buzz Aldrin and Malcolm McConnell, Bantam Books, 1989.

Pioneering the Space Frontier: The Report of the National Commission on Space, Bantam Books, 1986.

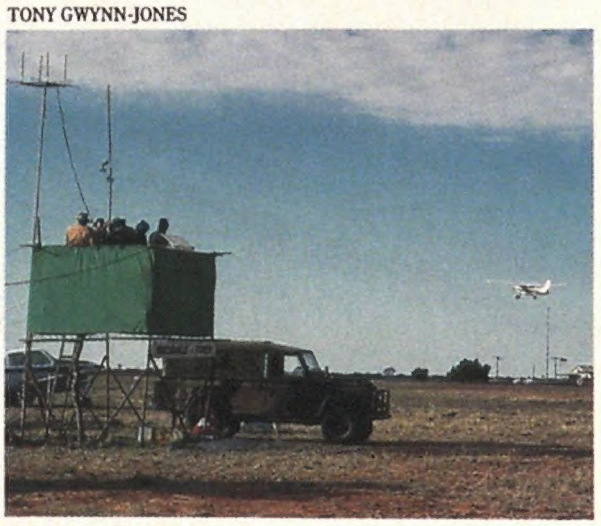
Stages to Saturn, R. Bilstein, NASA, 1980.

"The Satellite Sky" Update will resume in the next issue of *Air & Space/ Smithsonian.*

Forecast

In the Wings . . .

TONY GWYNN-JONES



The Annual Birdsville Bash—One weekend every September airplanes and revelers from all over Australia descend on a dusty one-pub town in the Outback for a few horse races and a very large and lively party.

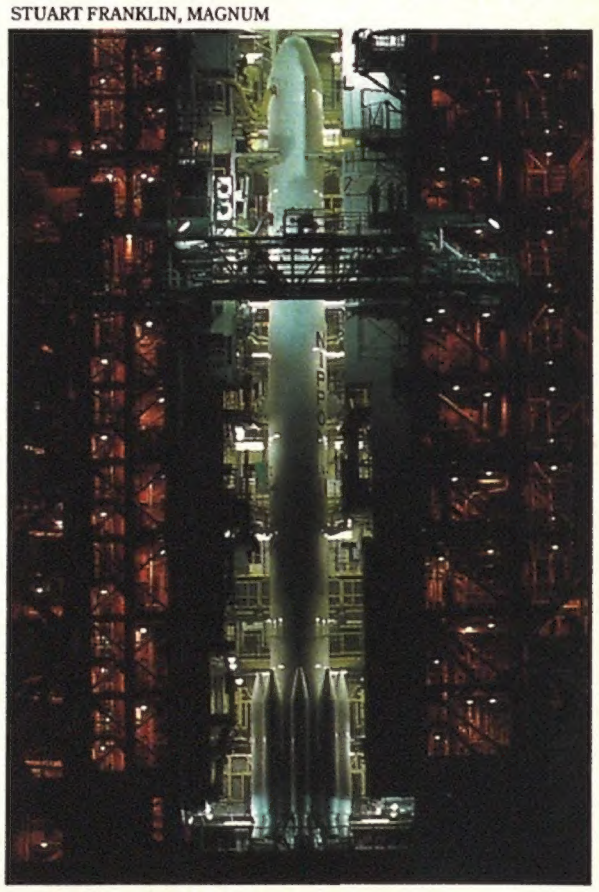
Son of Skylab—NASA's Long-Duration Exposure Facility was launched from the shuttle in April 1984 for an 18-month orbit and has been waiting for a ride home ever since. Now the untended laboratory and its experiments are scheduled to return this year—in roughly 430 pieces. Like Skylab, which disintegrated during reentry in 1979, LDEF's orbit has been decaying from increased friction in the upper atmosphere caused by massive solar flares. It will plunge back to Earth in December unless NASA can bump a defense department payload off the backed-up shuttle manifest and grapple the satellite into the shuttle's payload bay.

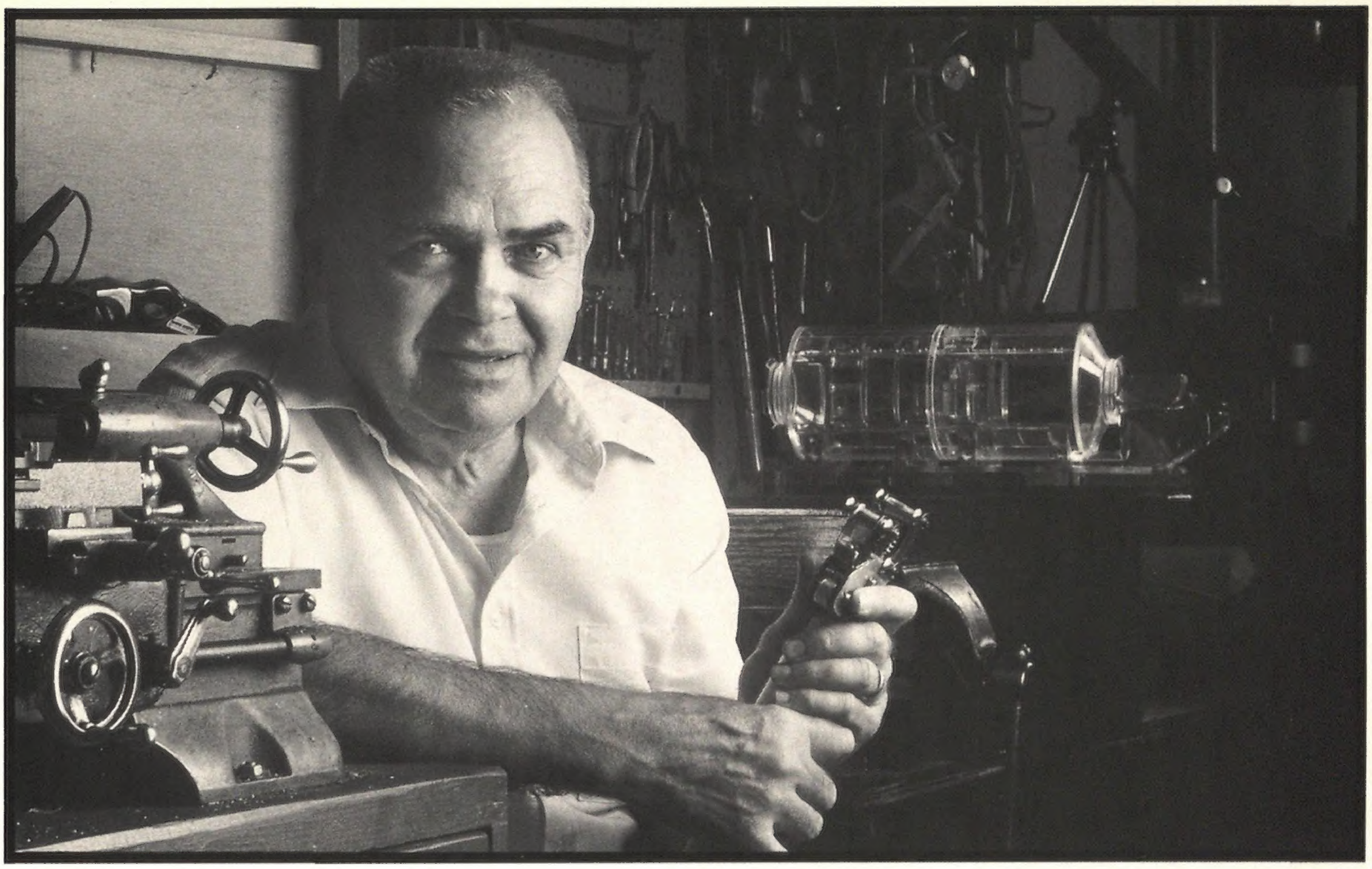
Flight in the Comics—In the 1930s and '40s, many comic book heroes and villains took to the air, and their creators were faced with designing the appropriate method or vehicle of flight. In the world of comic books, it was the golden age of the generic airplane.

High-Tech Parachutes—"Need a tank somewhere right away?" asks Carl Peterson. "Want to recover a scientific package from space? Drop peanut butter and jelly sandwiches to some guys in the front lines?" At Sandia National Laboratories, Peterson and his colleagues wrestle with fluid dynamics, computers, and sewing machines to design parachutes for a multitude of tasks.

Japan's Space Program—In an overcrowded nation with few natural resources and a minuscule space budget, it's practicality, not prestige, that determines which space-based projects are undertaken. On the drawing boards are an aerospace plane, a shuttle, a microgravity research facility, and a NASA space station adjunct. And Japan's decisions about where it will place its bets exert a powerful influence on similar programs in Europe and the United States.

STUART FRANKLIN, MAGNUM





"It's not easy for an astronaut to build anything up there...what they really needed was a fastener that would help them put those space structures together quick and easy.

My job is solving these puzzles. This time I designed a self-aligning bolt for them. But I couldn't help thinking those gloves they wear could be trouble. So I went home and did some work on my own. Cut up a cookie sheet and found an old gear in the garage—used them to make some modifications on a cordless screwdriver. Turned it into a push-button wrench that'll let anybody—astronaut or robot—screw that bolt together in seconds.

If you keep on thinking, one interesting idea just naturally seems to lead right on to the next one." *—Earl Cooney, Space Station, Industrial Engineer Advisor*

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